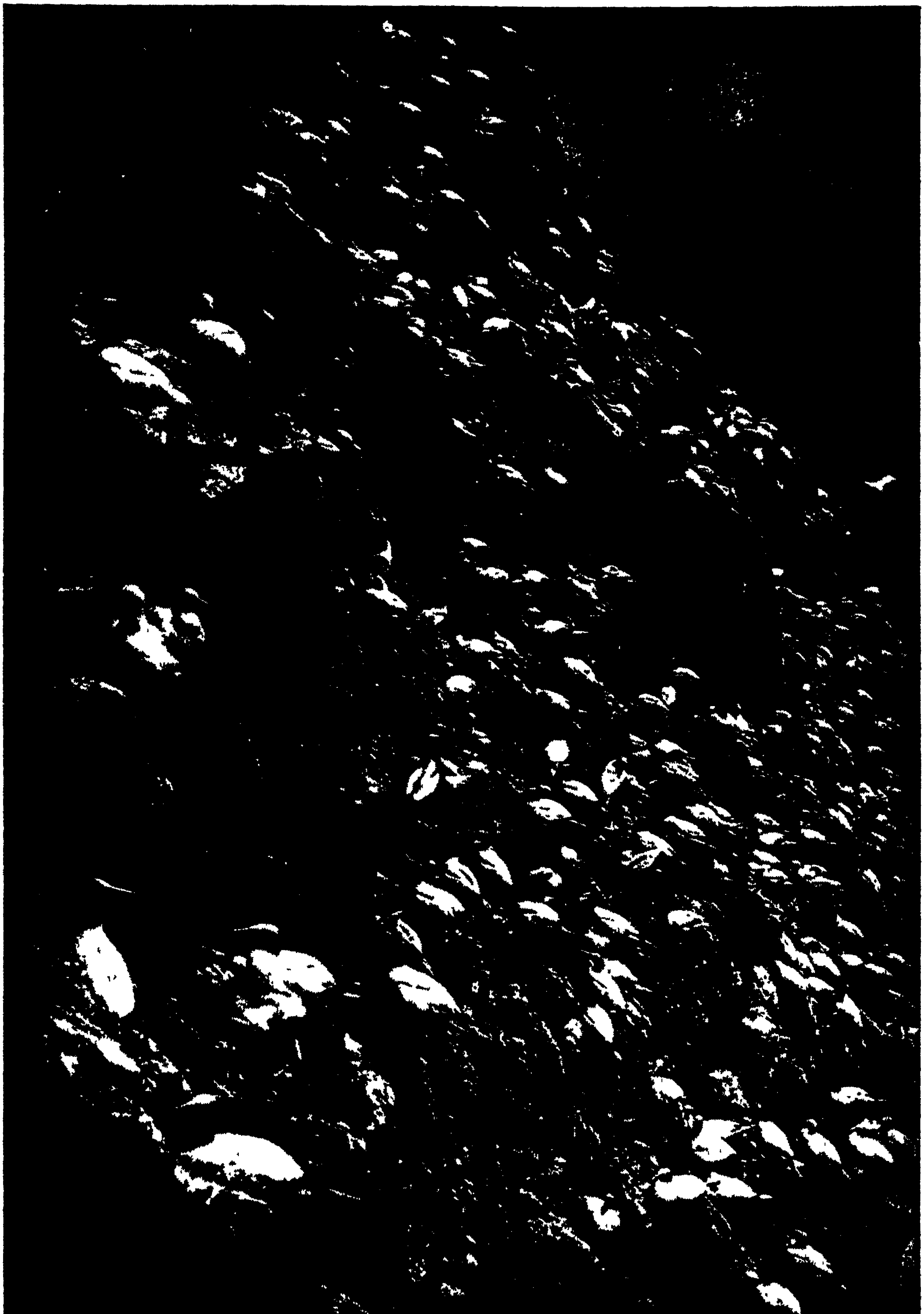
THE ONLY HOME THE SEA-BIRD KNOWS



GANNETS ON THE BASS ROCK DURING THE NESTING SEASON

A single egg is laid in a crude nest of seaweed.

The Book of

POPULAR SCIENCE

The Wonders of Modern Discovery
The Triumphs of Inventive Genius
The Story of all Created Things and
the World They Live In

EDITED BY

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CONTENTS OF VOLUME XI

A COSMIC BOMBARDMENT

How Twenty Million Meteors Rush Every Day into the Earth's Atmosphere and are Burned up by Friction

THE CELESTIAL MESSENGERS' STORY

A GREAT shower of shooting stars, which is a magnificent spectacle, is of rare occurrence, but anyone who watches the heavens on a clear, moonless night may see within an hour more than a dozen of these bodies appearing as swiftly moving points of light darting across the sky, and visible usually for somewhat less than a second. Besides these isolated examples, small showers, seen only by assiduous watchers, occur almost every night; but the chief displays of celestial pyrotechnics, including many thousands of shooting stars, and lasting throughout whole nights, occur at intervals with a regular periodicity.

Sir Robert Ball, the astronomer, gives the following description of the extraordinary shower of fire on the night between November 13 and 14, 1866, which shows the impression that display made on him: "The night was fine, the moon absent. The meteors were distinguished not only by their enormous multitude, but by their intrinsic magnificence. I was engaged in my usual duty of observing nebulæ with Lord Rosse's great reflecting telescope. I was, of course, aware that a shower of meteors had been predicted, but nothing that I had heard prepared me for the splendid spectacle so soon to be unfolded. It was about ten o'clock when an exclamation from an attendant by my side made me look up from the telescope, just in time to see a fine meteor dash across the sky. It was presently followed by another, and then again by others in twos and threes, which showed that the prediction of a great shower was likely to be verified. . . . For the next two or three hours we witnessed a spectacle which can never fade from my memory. The shooting stars gradually increased in number, until sometimes several were seen at once. Sometimes they swept over our heads, sometimes to the right, sometimes to the left, but they all diverged from the east. As the night wore on the constellation Leo ascended above the horizon, and then the remarkable character of the shower was disclosed. All the tracks of the meteors radiated from Leo. Sometimes a meteor appeared to come almost directly towards us, and then its path was so foreshortened that it had hardly any appreciable length, and looked like an ordinary fixed star swelling into brilliancy and then as rapidly vanishing. Occasionally luminous trains would linger on for many minutes after the meteor had flashed across, but the great majority of the trains in this shower were evanescent. It would be impossible to say how many thousands of meteors were seen, each one of which was bright enough to have elicited a note of admiration on any ordinary night." Such were the showers chronicled in olden times as heavenly portents, and recognized by modern astronomers as recurring with wonderful regularity.

There is also a clearly marked and regular periodicity in the frequency with which isolated meteors fall, and appear as shooting stars. More than twice as many are to be seen during the early morning hours as in the evening, the maximum being usually about two or three o'clock in the morning; and more than twice as many fall during the latter half of the year as are visible during the earlier half.

We have already seen in many ways what importance meteors have assumed in modern astronomy, thus, they are regarded as the materials out of which planets are formed, and we last met with them as the probable constituent elements of the rings which encircle the planet Saturn Shooting stars also are meteors, which encounter the atmosphere of the earth. A shooting star is a solid body, usually of iron or of stone formation, quite cold and dark; the average velocity of meteors is about 25 miles a second, but they enter our atmosphere at very different speeds. For the earth itself is moving at a speed of somewhat over 18 miles a second, and consequently, if the meteor is traveling in the opposite direction to the earth so as to meet us, its apparent velocity may be more than 43 miles a second; but if it is overtaking us, its velocity relative to the earth may be not more than 8 or 10 miles a second

But this initial velocity relative to the earth, whether greater or less, is quickly retarded by the resistance and friction of the atmosphere into which the meteor has plunged; and the brilliant light, which is all that we usually see of the shooting star, is caused by the incandescence of its materials through the great heat evolved by that friction.

The velocity of meteors and the heat generated by them

It is calculated that the average velocity of a meteor on entering the earth's atmosphere is about a hundred times that of a rifle bullet, and that the latter velocity is sufficient to heat the bullet by 10° F. in the course of its flight. Inasmuch as the heating power of the atmospheric friction is proportional to the square of the velocity of the flying object, the flight of a shooting star is swift enough to produce ten thousand times the amount of heat generated by that of a rifle bullet.

Such an enormous development of heat is of course many times more than sufficient to light up a small meteor, converting it first into a shooting star, and then swiftly dissipating its materials in the form of fine dust. And since the amount of light produced depends upon the mass and the velocity of the shooting star, it is certain that the mass of most of these bright evanescent objects is extremely small, perhaps hardly amounting to a grain in weight, for otherwise the light would be greater than it generally is. Occasionally, however, the masses which enter the atmosphere of the earth are so large as to survive the great heat developed by their journey through it, and they fall to the ground in solid form Some of these greater meteors, when the fragments into which they have been broken by the fall have been fitted together, have been found to weigh hundreds of pounds These great projectiles are, however, quite exceptional among meteors

It has been calculated that twenty millions at least of these meteoric bodies enter the atmosphere every day. The overwhelming majority are not visible at all, owing to the presence of sunlight, moonlight and clouds

How far away does a meteor's blaze become visible?

The above calculation is based upon the comparatively small number observed from any one point on the earth's surface throughout a clear, moonless night. But if those shooting stars were also included which are too small to be seen without a telescope, the estimated number would have to be increased twenty-fold The astronomer who watches the skies with a large telescope sees meteors darting across the field of his vision with great frequency.

Exceptionally brilliant meteors, known as "fireballs", when entering the atmosphere at the swiftest speed, become incandescent, and therefore visible, at a height of about 80 or 100 miles above the earth's surface; those which are moving more slowly relatively to the earth begin to blaze at a height of about 50 miles; and ordinary shooting stars shine first at an elevation of about 62 miles. In the vast majority of cases the career of brilliancy is brief; most meteors cease to be visible at a height of about 40 or 50 miles above the surface of the earth, though some fireballs are seen as far down as 5 or 10 miles.

The length of the path traveled by a meteor during the period of its shining depends to a considerable extent on the angle at which it falls, and may be anything from 50 to 100 miles, the average path being estimated as 40 miles.

Shooting stars may usually be traced throughout a space of 40 or 50 miles; but fireballs, especially when of the slower velocities, and when seen near the horizon, almost always traverse a path of over 100 miles in length.

The illusion as to the size of meteors because of luminous air

Some meteors, and especially the rarest and most resplendent fireballs, look very much larger than they really are Indeed, their diameters sometimes appear to be as large as that of the moon, from which we should naturally judge that they had a real diameter of several hundred feet. But this is all an illusion which is easily accounted for. In reality, the very finest meteors, when they enter the atmosphere, do not weigh more than, say, 1000 or at most a few thousand pounds, nor in all probability do their diameters extend to 10 feet at the most. The largest single mass which has been seen to fall to earth — in Hungary, in the year 1866 — weighed less than 600 pounds, though a number of much larger meteorites have been discovered after their fall; thus at least four found in North America have individual masses of 10 tons or more and the largest one brought back from Greenland by Peary weighs 73,000 pounds. Many bright meteors are probably not larger than a grain of sand. The great amount of light produced is due partly to the glare of the momentary combustion, and partly to the fact that they are surrounded, during combustion, by an envelop of hot air and smoke that becomes luminous, and so greatly exaggerates their apparent dimensions.

The meteorites that reach the earth's surface are of great interest, as being specimens of extra-terrestrial materials, which can be inspected and analyzed. A great number of these bodies have been found, many having been seen to fall, but by far the majority have been distinguished as meteorites because of their physical characters. Farrington, in his very complete "Catalogue of Meteorites of North America", states that of the 600 or more meteorites known in the world up to 1909, 247 had been found in North America: of these 161 are classified as iron meteorites, 10 as iron-stone meteorites and the other 76 as stone meteorites. Out of the 171 members of the first two classes only four were actually seen to fall, while of the 76 stone meteorites 56 were seen to fall.

There are valuable collections of meteorites in the Yale, Amherst and Harvard museums; in the National Museum, Washington; the American Museum of Natural History, New York and the Field Museum of the University of Chicago

The crust of meteors — how, and of what, it is formed

A characteristic mark of meteoric masses is the thin dark-colored crust or glazing, formed by the intense heating of their surface for the very short period of their passage through the air. This crust is usually not more than one-100th of an inch thick, due to the fact that the air through which the meteor rushes carries away the melted surface leaving only a very thin film of glazing.

This crust is actually a black glass containing many small bubbles; it consists largely of oxide of iron, and is highly magnetic. Occasionally there is also an inner layer of incompletely fused matter, containing particles of iron which have neither been melted nor oxidized. As a rule, the crust and the rest of the mass are clearly distinct from one another, they do not blend nor mingle, except where sometimes the glazing has apparently flowed through veins and fissures into the more or less crystalline mass of the meteorite. The crust is often of unequal thickness in different parts of the same meteorite, and forms ridges as the result of a flowing movement in the melted material. The forward part of the meteorite, which meets the pressure of the air with the greatest force, becomes the most readily and fully liquefied, and the molten glaze flows backward.

Another common peculiarity of the crust is the appearance of numerous small "thumb-marks" or depressions, sometimes all over the meteorite, and sometimes on certain portions of the surface only. These may be due to the action of the air in driving off small portions from the melted surface, or, as is more probable, to the varying effects of heat and air on the different materials forming the meteorite, the holes representing the burning out of certain more fusible substances during flight; but the cause has not been determined with absolute certainty.

The fallen masses, when found, present the appearance of broken fragments, being of irregular shape, and often having many angular points. The various fragments which were picked up from the meteorite that fell at Butsura, India, were fitted together, and formed one complete mass of regular form, except for one corner. Most of the fragments were coated all over with the typical glaze, showing that the explosion which separated them took place early in the meteor's career through the atmosphere; in other fragments, however, the faces which fitted together were not crusted, so that these must have been split apart by a later explosion, when the velocity of the meteor, and consequently the production of heat, had been reduced.

By the time they reach the earth's surface, meteorites are found to be still hot, but not, as a rule, hot enough to char wood nor soft enough to receive any impression of the surface upon which they fall. Instances are on record, however, in which the mass was found to be still glowing hot on reaching the earth.

The number of fragments in which a meteorite falls to the ground varies greatly; sometimes the mass arrives intact, sometimes in thousands of little pieces, but it is usually broken into several parts.

Meteorites fall, of course, in complete independence of weather conditions or of any other terrestrial circumstance. But the fall is often accompanied by violent detonations; and these, together with the brilliant flashing of the fireball, give to the phenomenon a general character not unlike that of the loudest thunder.

The fire and smoke which mark the path of the speeding meteor

The heat generated by the resistance of the atmosphere to a meteorite traveling with the initial velocity of 25 miles or more a second is many hundred times greater than that produced by the burning of an equal quantity of coal, and is far in excess of the heat required to melt the most refractory metals The heat and the pressure together are answerable for the explosions of the meteorites.

Long trails of smoke are often observed following a fireball. They are doubtless due to masses of molten matter swept away from the surface of the meteorite and turned to vapor by the heat of the surrounding air. Fresh layers of surface continue to be thus fused and swept away until the velocity of the meteorite has become retarded to about 2 miles a second, when the heat and the rush of air are no longer sufficient to melt and remove the material, and the fused surface cools and solidifies, forming the characteristic crust.

The sensations of onlookers witnessing meteoric falls

Very few of the big showers of shooting stars have been known to yield meteorites. An exception was the Mazapil meteorite which fell in Mexico in 1885.

The Thwing meteorite fell on the afternoon of a calm, hazy day, when there was no sign of thunder A loud explosion was heard, followed by a hissing noise, and then by a shock as of some heavy body falling to the ground. The sounds were heard over a considerable area, and people ran to see what was the cause. A plowman saw the meteorite fall not far from where he was standing. It was found to have penetrated through the soil, and for several inches into the solid chalk beneath.

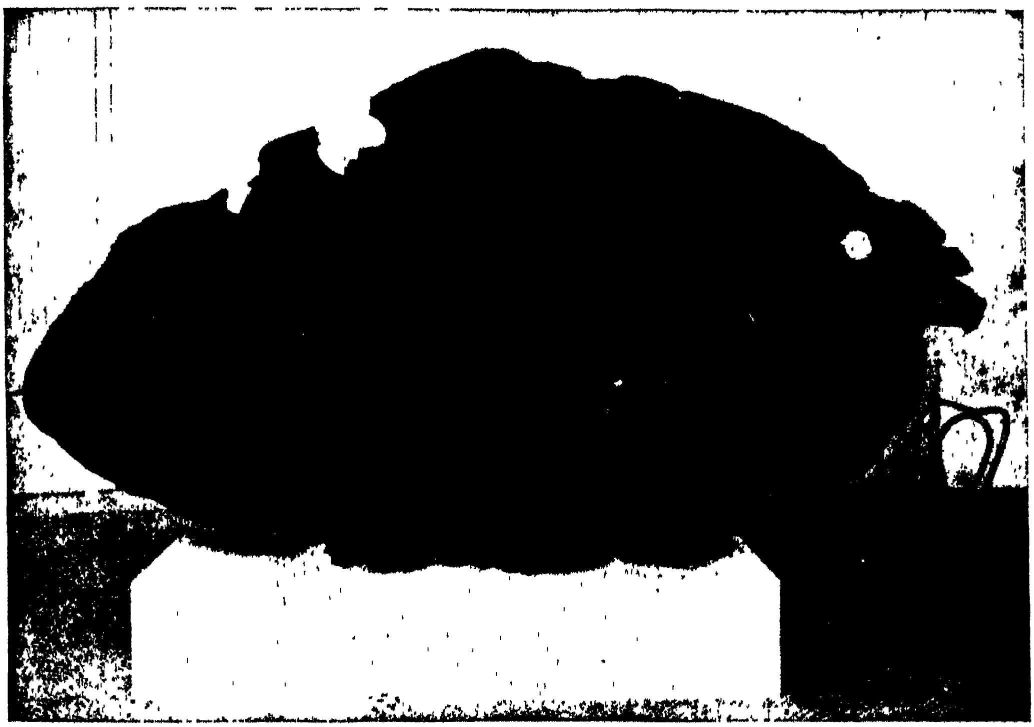
The Middlesbrough meteorite, which is of a low pyramidal shape, and measures 5 by 6 inches, with a height of 3 inches, fell during bright sunshine on a calm, clear day. Its fall was accompanied by a rushing or roaring sound overhead. Three minutes after its fall it was found to be slightly warm when drawn out of the

round, vertical hole it had made. It is unusual for a meteorite to penetrate the earth in a vertical direction. Most of the holes made by these bodies prove that the fall took place in an oblique direction.

The oldest existing meteorite of the fall of which we have authentic record is still shown in the town hall at Ensisheim, in Alsace, where it fell on November 10, 1492. It weighed originally 260 pounds, and penetrated to a depth of 5 feet.

Meteorites may be divided broadly into two classes, according as they are composed chiefly of stone (aerolites) or chiefly of iron (siderites), but between these two kinds there is a great variety of combinations of both. Sometimes the iron forms a sort of spongy framework within which stony masses are embedded; sometimes, on the contrary, the stone forms the basis, and larger or smaller masses of iron are disposed throughout it. Some authorities believe the aërolites to be of terrestrial origin and the siderites to be portions of disintegrated comets.

Meteoric iron is an alloy that is not represented among the mineral products of our earth; it consists of from 80 to 95 per cent of iron, combined with from 6 to 10 per cent of nickel. The presence of nickel gives to meteoric iron a whitish appearance, and prevents the outer surfaces from rusting, as ordinary iron rusts. More than a dozen of the mineral constituents of meteorites have not been so far discovered among terrestrial minerals. Meteoric stone, on the other hand, is composed of minerals which are found upon the earth, in lava and other volcanic products. It is specially notable that carbon is occasionally present in the form of indistinctly crystallized diamond; in the famous Canyon Diabolo meteoric masses many small black diamonds have been found and in one piece there was discovered a tiny white diamond one-50th of an inch in diameter. Carbon is sometimes present also in the form of graphite. Many of the common mineral compounds of our earth are, however, entirely wanting in meteorites; for instance, quartz, the commonest of terrestrial minerals. No free quartz in any form has ever been found in a meteorite.



THE WILLAMETTE METEORITE FROM OREGON, SHOWING THE DEEP PITS FORMED BY OXIDATION

Though meteorites contain *minerals* not found on the earth, nevertheless the *chemical elements* of meteorites are all represented among our known chemical elements, and are almost all common among these. About one-third of the known terrestrial elements, including helium, have been found in these bodies. The most frequent, or most plentiful, are iron, nickel, magnesium, calcium, aluminum, carbon, oxygen, sulphur, silicon and phosphorus. Less frequent, or present in smaller quantities, are hydrogen, manganese, cobalt, copper, lithium, sodium, potassium, strontium, titanium, chromium, tin, chlorine, nitrogen, vanadium; and occasionally minute traces are found of gold, platinum, gallium and iridium. Some analysts have also reported the presence of arsenic, antimony, lead and a few other elements; but an exhaustive study of the chemical constitution of meteorites made by George P. Merrill, Head Curator of Geology, United States National Museum, makes the presence of these elements very doubtful. Iron occurs almost always, as we have said, in combination with nickel, phosphorus almost always in combination with both.

The extraordinary train of light which may be left by a fireball

No trace of organic matter of any kind has ever been discovered in meteorites; they bring us, therefore, no evidence of any living beings beyond our earth.

We have already seen that the fall of a meteorite is often accompanied by the appearance of a fireball, but many fireballs sweep across the sky without yielding, so far as we know, any meteoric fragments. A fireball is a shooting star of exceptional size and brilliancy, and is usually more or less pear-shaped. It appears with startling suddenness, and resembles a superb mass of liquid fire moving across the sky and falling earthwards in a sweeping curve. Not infrequently a fireball leaves behind it a train of ruddy sparks or a curved streak of light, and this luminous train often remains for some minutes, and has been observed as long as forty-five minutes after the passage of the meteor.

The origin of meteorites neither terrestrial nor atmospheric, but cosmical

Both the path of the fireball itself and the form of the trail which it leaves behind it show irregularities in their curves, due to the force of the currents of air. Some fireballs move as swiftly as ordinary shooting stars, but the finest ones move much more slowly; they radiate, as a rule, from near the horizon, and pursue a more or less horizontal path of a hundred miles or more in length before they disappear. A particularly resplendent fireball was seen during the star-shower of November, 1833, over Niagara Falls. It had the appearance of remaining for some time almost stationary high over the falls, giving off radiant streams of light in all directions. If a fireball falls in the daytime, the ball of fire and the train are seen only as white clouds, their brightness being invisible in the far greater brilliancy of sunlight.

As to the origin of meteorites, as distinct from aërolites, it is now fully established that they are cosmical and not terrestrial nor atmospheric phenomena. The idea of stones falling from heaven was hinted at from the earliest times, but was scorned by men of science until comparatively recent years. The ancient popular belief is shown by the veneration in which a number of such stones were held; of these the most noted example is the base on which was erected the statue of Diana of the Ephesians, tradition stating that this stone had fallen from the skies. It is now known that inconceivable multitudes of these bodies infest space; that they move in regular orbits round the sun in accordance with the law of gravitation, that they are invisible to us until they enter our atmosphere and become ignited by the friction due to their passage through it; that, having entered the terrestrial atmosphere, few, if any, can again escape from it, but fall towards the earth, and are reduced to imperceptible dust; and that some of the larger survive the passage and fall to the earth's surface, providing us with practical evidence as to the physical nature of bodies outside our planet.

The identity in composition of meteoric masses

There is no reason to suppose that there is any radical difference between the nature of the meteors which reach the earth's surface and that of any others, including the showers of shooting stars. All these phenomena present the same features, although none of the great showers has been known to result in the fall of meteorites to the ground, with the possible exception of the Mazapil meteorite above referred to. Inasmuch, therefore, as we are able to put together what we learn from meteorites with what we learn from the showers of shooting stars, meteors form a most valuable source of knowledge, especially, as we shall see in a later chapter, in connection with comets, for the close relation between comets and shooting stars is amply demonstrated by the history of some of the great showers and of certain comets.

Problems of the direction of meteoric flights solved and unsolved

At regular times, as we have seen, meteors appear in great numbers, many thousands of them within a few hours, darting in all directions across the sky. But when these directions of flight are carefully observed, it is found that all of them, with perhaps a very few exceptions, diverge from one point in the sky, known as the "radiant". All the lines of direction, if produced backward, meet in this point; and the position of this radiant among the fixed stars is the same from whatever place on the earth it is observed. It is evident, therefore, that there is no actual point from which the meteors do, in fact, diverge. The effect is due simply to perspective; the meteors move actually in parallel lines and the radiant represents the vanishing point. A line drawn from the radiant to the observer gives, therefore, the actual direction of these parallel lines.

The position of the radiant depends entirely upon the direction in which the meteors are moving relatively to the motion of the earth.

But the particles which constitute meteors are of extremely irregular form, and they are consequently apt to be deflected somewhat from their course when they enter the atmosphere; and, further, it is unlikely that they travel in precisely parallel lines. On this account the radiant is not actually a point but is a small area in the sky, which is seldom, however, as much as two degrees in diameter.

In the case of showers which last for days or weeks, the position of the radiant is found to move slowly among the stars night by night. This change is due to the change of direction in the earth's motion, and is exactly what we should expect, since the position of the radiant depends upon the combination of the direction of the earth's motion with that of the meteors. Some exceptions have, however, been observed. In some cases the radiant is found to maintain its position among the fixed stars, notably in the case of the showers known as "the Orionids". This shower lasts from October 10 to 24, and its radiant point remains stationary the whole of this time No explanation of this and other exceptions to the general rule has yet been found

The mapping out of the courses of the meteorites

The radiants of about a hundred different recurrent showers are now catalogued The most important of these are: The Leonids, November 13–14; the Andromids, November 27; the Perseids, near the middle of August; the Draconids, January 2; the Lyrids, April 20; the Aquarids I., May 6; the Aquarids II., July 28; the Orionids, October 10–24 The names of these showers are of course derived from the situation of their respective radiants; for example, the Leonids all radiate from a point within the constellation Leo.

As early as 1811, some idea of a possible periodicity in the motions of meteors seems to have occurred to astronomers; and in 1833, when the fact of the radiant and its meaning were clearly recognized, Professors Olmsted and Twining, of Yale, showed that this regularity of movement

in a large swarm of meteoric bodies was evidence of their cosmical origin, and of their motion in regular orbits round the sun. It was Professor Hubert A Newton, also of Yale who, just before the recurrence of the Leonid shower in 1866, completed very laborious researches which brought to light historical records of brilliant star-showers on sixteen occasions in October or November, the earliest on record being in the year 902. The dates are at intervals or multiples of thirty-three years, while the day of the year has moved along the calendar at the rate of one month in a thousand years. Part of this alteration in date is accounted for by the change in the calendar, the actual variation in the date of the shower being about one day in seventy years. This gradual change of date implies a gradual change in the position of the orbit of the meteors, for if this had remained constant, the shower would always have crossed the earth's orbit in exactly the same place.

It was possible to calculate which of the planets would be able to produce the perturbations necessary to cause this change of orbit, and so to provide data for the determination of the orbit itself. From the direction of the Leonids, given by their radiant, and from their periodicity, it was found that there were five possible orbits for them — one long ellipse which required the whole of the thirty-three years to traverse; two almost circular orbits, one a little longer and the other a little shorter than the earth's path; and two smaller ellipses contained within the orbit of the earth. The calculation of the perturbations required to produce the change in the orbit made it possible to decide that the great orbit of thirty-three years is the true one.

This having been determined, another very interesting fact emerged. The orbit of the Leonids does not intersect the paths of Jupiter or of Saturn, but it does intersect that of Uranus; and Le Verrier showed that in the year 126 Uranus was at this place of intersection just at the time when the swarm of meteors was there. It is believed that this encounter fixes the date at which the Leonids received their present determinate orbit.

Courtesy Canadian Pacific Railway

THE BEAUTIFUL YOHO GLACIER, FIELD, BRITISH COLUMBIA

JOURNEYINGS OF THE ICE

How the Glaciers, as Travelers and Burden Bearers, Engineers and Engravers, Tell the Story of the Past

GLACIAL CREEPINGS NOW AND LONG AGO

RIVERS of ice, like rivers of water, do a certain amount of carrying and carving. As a glacier crawls down from the mountains to the plains, it carries on its back a burden of boulders and stones and soil. All the way down it digs away at the hillside and brings down upon itself a load of rubble. Rain, avalanches and little landslips serve to increase the load, and ultimately there are two long stripes known as "lateral moraines" or ridges of débris, one to the right and one to the left. When two glaciers unite, their two contiguous lateral moraines unite, and take up a central position on the joint glacier, making what is called a "median moraine". Usually toward the end of a glacier the lateral and median moraines are no longer distinguishable, and the stones and débris are scattered broadcast. Attached to the under surface of a glacier there is also a certain amount of soil and stones, forming what is called the "ground moraine". When a glacier melts and retreats it deposits the collection of stones and soil that has accumulated at its end, and this deposit is known as a "terminal moraine", and shows where a glacier once was, long after it has melted away.

The amount of débris thus transported may be very large, for to such a leviathan as a glacier no rock is too heavy. The moraines may form ramparts as high as 80 or 100 feet, and individual blocks may measure thousands of cubic yards. In the Valley of Saas there is a boulder of serpentine 1000 cubic yards in bulk. The stone called the Pierre-à-Bot, measuring 40,000 cubic feet, weighs 3000 tons. It is some 50 feet long, 40 feet high, and 20 feet wide Yet it must have been carried sixty or seventy miles, and in all probability crossed the Lake of Neuchâtel. The Pflugstein, near Zurich, 60 feet high, 72,000 cubic feet in volume, and 4500 tons in weight, must have come across Lake Zurich from the Alps of Glarus. Near Monthey, in the Lower Valais, there is a belt of granite boulders, which stretches for miles above the left bank of the Rhône, near its junction with the Lake of Geneva. These Blocks of Monthey must have come from the Valley of Ferret, thirty or forty miles away; and one of them, the Pierre des Marmottes, is 60 feet long, 30 high, and 33 wide, with a volume of about 55,000 cubic feet.

Among the many erratics found in New England some are worthy of note. Massachusetts claims one at Bedford, weighing 2300 tons and another at Fall River, 5400 tons; Connecticut boasts of one near Montville 65 feet long, 60 feet wide, and 55 feet high, nearly 10,000 tons in weight.

Quite apart from such prodigies, the amount of material borne by glaciers as moraines may be very large; and if the glacier has been alternately advancing in summer and retreating in winter, a terminal moraine may represent the deposit of many years. In some cases, there are several heaped-up terminal moraines, one behind the other, showing that the glacier has retreated or advanced intermittently. In North Italy terminal moraines are found which rise out of the plains of Piedmont as mountains 1500 or 2000 feet high.

The enormous thickness of the ground moraine in the Greenland glaciers

The ground moraine in the case of most mountain glaciers is quite inconsiderable, and little more than a smear of mud and a sprinkling of stones; but in the great polar glaciers the amount of detritus carried along as ground moraine may be immense. In all the Greenland glaciers this moraine is 100 or 150 feet thick, consisting of clay, earth, stones and sometimes large boulders, scattered through the ice. In the lowest 12 or 15 feet the whole glacier seems to be composed of black débris. In the Spitzbergen glaciers the same condition obtains. When glaciers of this type diminish or disappear they leave their track covered with earth and stones resembling the "boulder clay" and glacial drift found in various parts of Europe and America Round the Booming Glacier, in Spitzbergen, where it has shrunk from larger dimensions, there are some square miles of tough mud which, if dried, would exactly resemble boulder clay

The tremendous pressure with which glaciers grind the hardest rocks

As we said, glaciers both carry and carve Such enormous, weighty, moving Juggernauts must crush and grind as they move along, especially as they often, if not always, have sand and stones and rocks embedded in their lower surface. A glacier 1000 feet thick presses with a weight of over 500,000 pounds on every square yard of its bed; and though it may grind slowly, yet it grinds exceeding small Even the hardest rocks are filed down and scored with scratches and ruts; and any collection of rocks which have been under the glacier present characteristic rounded forms like a flock of sheep lying-down, or the backs of plunging dolphins. Rocks ground by glaciers into such rounded forms are known as "roches moutonnées", since De Saussure, who first described them, compared them to well-dressed fleeces, or the wigs, styled in his day *moutonnées*. Sometimes roches moutonnées are polished and smooth, but more often they are scratched.

The part glaciers play in remolding the surface of the earth

That glaciers can do so much is certain; and the only question is, how much more can they do? They can rub away rocks undoubtedly, but can they gouge out valleys? And are their valley-making efforts to be compared with the achievements of rivers? On this question there is a difference of opinion Some hold that such huge excavations as the beds of the Swiss lakes and of the Great Lakes were dug by glaciers, others consider them quite incapable of such big work On the whole, it is probable that they act rather as planes than as spades, and the deeper lake-beds and mountain valleys are not their work

Whatever work glaciers do effect, they are aided, to a great extent, by the streams that issue from and flow with them The water which flows from the lower end of a glacier is always muddy, and the mud represents a considerable amount of wear and tear, but wear and tear produced, perhaps, as much by the water as by the hard heel of the ice Dr. Albert Heim, the Swiss geologist, who has specialized on glacier study, calculates that the débris "removed annually by all the Justedal glaciers, in Norway, is equal to a cube of rock measuring 134½ feet on each side." And it has been calculated that during August the stream issuing from the Aar glacier carries away 280 tons of sand daily.

The water that flows down through the crevasses of glaciers, and drills a hole or "moulin" through the ice to the underlying rock, often wears out the rock into gigantic potholes, known as "giants' kettles"; and where these are found we may be sure a glacier has been. Near Lucerne several of these potholes were found in soft sandstone, some being several yards in depth and in circumference, and many of them are to be seen in Norway and northern Germany. Striking examples are also found in the hard rock on the shores of Lake George. A deep one having the appearance of a well may be seen in the sandstone on the brink of Ausable Chasm near Lake Champlain.

THE ICE-FLOW FROM THE "CATHEDRAL" PEAK

THE MAGNIFICENT FÉE GLACIER, AS VIEWED FROM THE EGGINER RIDGE, SWITZERLAND

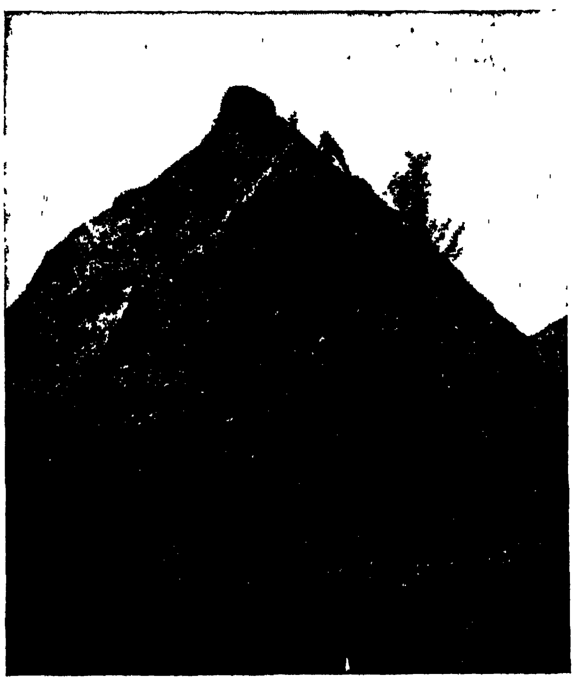
The puzzling problem of the erratic boulders and its solution

Such, then, is the work of modern glaciers, but there have been times when glaciers have been much busier than now, and a record of their travels is to be found in many lands. At one time, indeed, glaciers seem to have spread over the greater part of the northern hemisphere.

This is generally recognized now, but it was not even suspected till quite modern times; and it was really the big erratic boulders we have already mentioned that gave the hint to geologists. For years the "erratics" had been a problem and puzzle. No one could say how they came to be distributed in such a strange fashion. No one could say how such massive boulders had been carried such great distances, often up hill and down dale

The unlearned, feeling that the boulders required some explanation, fell back upon the preternatural, and usually came to the conclusion that the devil had had a hand in it, and had been using the stones as quoits, or marbles. Such imaginative explanations, however, did not quite satisfy geologists, and they tried hard to find an adequate scientific explanation.

At first it was thought possible that great explosions or deluges had lifted and dispersed them. But explosions could hardly fling stones weighing 3000 tons a distance of 60 or 70 miles; nor could a deluge, however tremendous, carry a boulder up hill and down dale, over one hill into another valley, as erratics are often carried. Efforts to explain their transport by icebergs and floating ice were equally unsuccessful; and until the first decades of the last century no one thought of transport by glacier Then the idea began to dawn upon men's minds, and this is how it happened



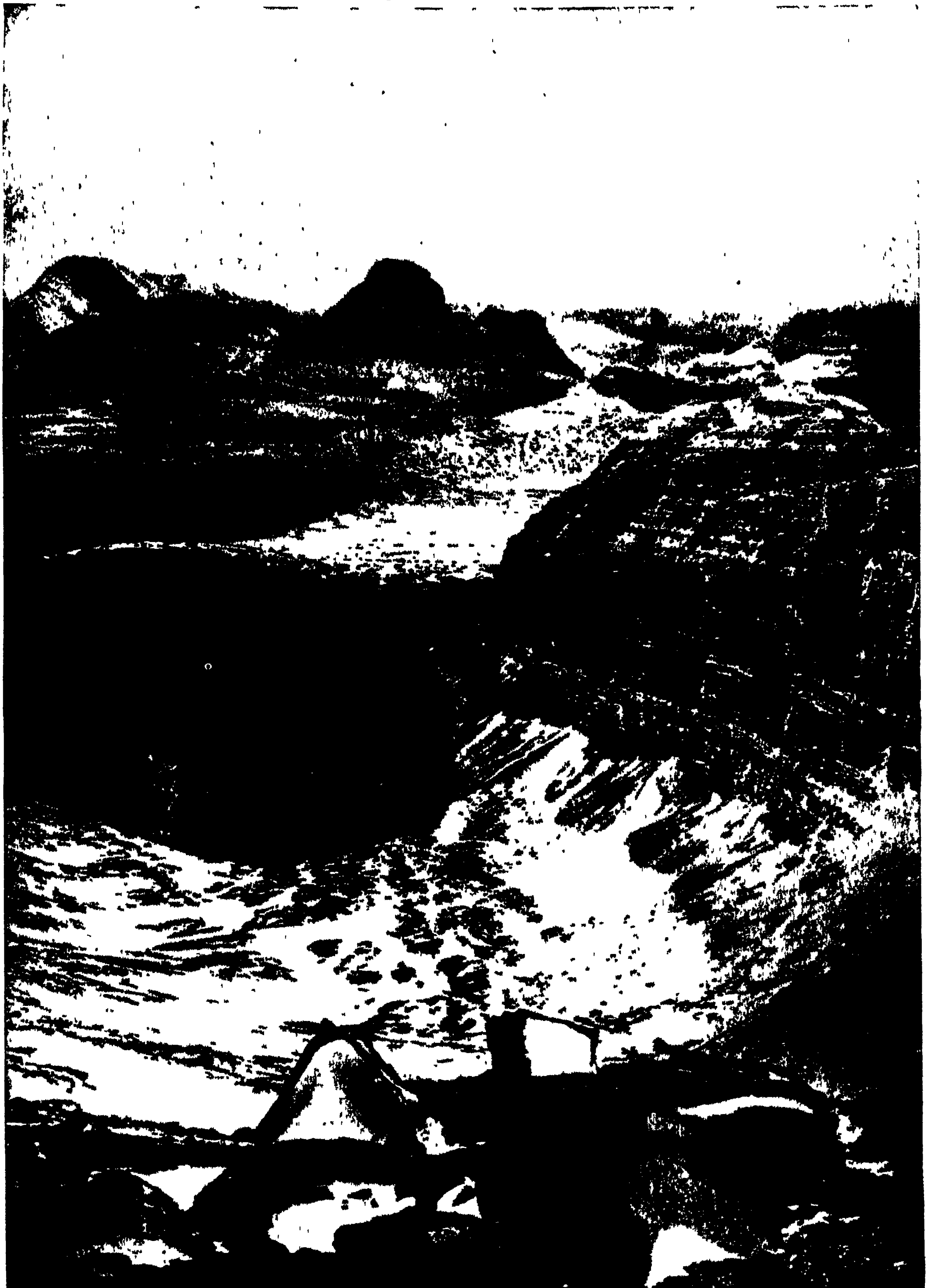
AN ERRATIC IN NORTHERN NORWAY

In 1815, Jean de Charpentier, director of the mineral baths at Bex, spent a night in the cottage of a chamois-hunter, and in the course of a conversation about glaciers the latter stated that the glaciers "had formerly a much larger extent than at present Our whole valley was occupied by a vast glacier extending as far as Martigny, as is proved by the boulders found in the vicinity of this town, and which are far too large for the water to have carried them thither."

In 1829, a Swiss engineer named Venetz, who had been investigating the glaciers of the Swiss Alps, expressed his belief to De Charpentier that the whole Valais had been formerly the bed of an enormous glacier, more than 180 miles in length, and that this glacier had carried to the Jura blocks from the Alps.

The idea fell on good soil. De Charpentier thought over the mountaineer's and engineer's ideas, and finally communicated them as a scientific theory to a meeting of Swiss naturalists at Lucerne. So bold and revolutionary was the theory that it met with great opposition. But a true theory will always find champions as well as enemies; and two young naturalists, Louis Agassiz and Carl Schimper, not only championed it, but developed out of it the greater theory of a Glacial Epoch. It was the logical outcome of the chamois-hunter's common sense.

SNOW-TOPPED PEAKS WHERE GLACIERS START



© Fred H. Kiser, Courtesy National Park Service

SOUTH FROM PIEGAN PASS, GLACIER NATIONAL PARK

If it required a glacier to carry the boulders to Martigny, it required glaciers to carry the boulders from the Alps to the Jura mountains, and to transport all the other erratics that were found in other localities.

Further, all over northern Europe and northern North America, ice had left its marks not only in erratic boulders, but in ruts and scratches and moraines, and roches moutonnées, and boulder clay, and "devils' punch-bowls" The more the matter was studied, the more certain it became that northern Europe and northern North America had once been under an ice-cap

The evidence pointing to a glacial period is only circumstantial, but it is many-sided and absolutely conclusive

Let us look, for instance, at the composition of boulder clay, or "till", as it is sometimes called It consists of an exceedingly tough, tenacious clay, mixed with grit, pebbles, stones and rocks in varying amounts The clay has evidently been subjected to great compression, and is so tough and compact that it is very difficult to excavate, and in some cases requires to be blasted out. The quantity and quality of the hard material in the clay vary considerably. Sometimes there are only a few stones sprinkled here and there; sometimes it is almost all stones. As a rule, there is more clay than stony material. The stones in the clay vary in size — they may be inches, or feet or yards in circumference. As a rule, they are from two to eight inches in diameter. Large or small are mixed higgledy-piggledy together. Now, it is obviously a very curious thing that stones of such varying sizes should be mixed up with clay in this way, like the raisins in a plum-pudding How did it come about? Who stirred the pudding?

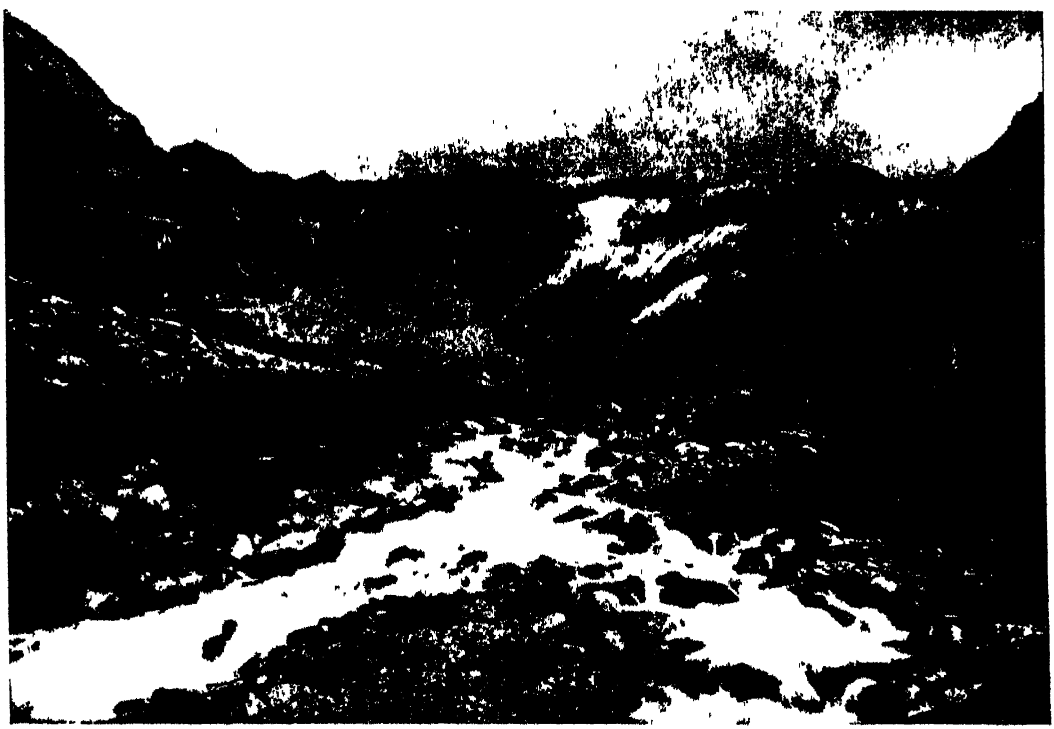
ROCKS TRAVELING ON A GLACIER

At one time it was thought to be the work of a deluge, and was even taken as a proof of the Flood But a deluge would have sorted out the material, as the waves sort out the pebbles in the shingle of a beach, and not a single instance has even been known of boulder clay deposits after a deluge — after such a deluge, for instance, as was caused in Bengal by the Backerzunge cyclone. Neither running water nor tidal water, neither river nor sea, could have made the boulder clay mixture, but only the white pestles of the glaciers mashing up stones and mud in the mortars of the mountains and valleys

Further, when we examine the stones and pebbles in the boulder clay, we find that they are not oval and round like stones and pebbles that have been rolled in rivers and on sea-beaches; they are rather flattened and angular, with rounded angles, and they are scratched, these scratches running usually parallel to their long axis. We do not find such scratches on stones which have been tossed and tumbled in rivers and oceans On the contrary, these are polished and smooth; and we must regard the scratches as the authentic signature of glaciers. The stones, moreover, show no weathered crust; they show no signs of chemical erosion by water and air; they are quite sound and unoxidized, as if they had been just blasted from a quarry. All these facts point conclusively to glacial action.

THE END OF THE ICE'S JOURNEYINGS

CLIMBING THE GREAT GLACIER, GLACIER, BRITISH COLUMBIA



TERMINAL MORAINE AND STREAM FROM THE GREAT GLACIER
Photos Courtesy Canadian Pacific Railway

But we can go further still. If we clear the boulder clay off the underlying rocks, we find that the rocks are all scratched and grooved Remarkable grooves in limestone are found on Kelley's Island in Lake Erie They are neatly carved and have a fluted appearance. The striæ also depend on the nature of the rock containing them Thus on the shores of Lake Champlain we find fine delicate lines in the compact limestone while, for example, in the exposures of the coarse Manhattan schist about New York, and notably in the Bronx Park, they are much rougher. What other tool save a glacier could have made such markings? Moreover wherever striated rocks are found, the scratches are from north or northeast to south or southwest, showing the direction of the glacier's flow Besides we find that the marking instrument has managed to scratch not only the prominences and bulges of the rocks, but has marked the bottom of every dimple and depression. Again, what graving-tool save a glacier could have done it? The sea could not have done it; rain and wind and frost could not have done it. The work is undoubtedly the work of moving ice, whose polishing-powder contained both sand and rocks.


GLACIER-POLISHED ROCKS IN NORWAY

Again, in some places boulder clay is a thin layer; in other places it may be a hundred feet deep, and in some places it may be more than five hundred feet deep, but over any area covered with boulder clay the depth varies in an irregular way, quite independently of the nature and height of the ground. This irregularity of deposition is characteristic of a glacier, and could have been effected by no other natural agent. Yet, again, the rocks and stones mixed in the boulder clay are usually not all local: a certain percentage of the stones comes from a distance of some miles. Only a glacier could account for this mixture. Only glaciers could form the roches moutonnées, which are not in the least like rocks worn by rain and frost and rivers.

Finally, to make assurance doubly sure, we find in the boulder clay the shells of arctic seas. Towards the end of the Tertiary Epoch, the climate of the world seems gradually to have become cooler. During the greater part of that epoch the world was warmer than it is now, as is shown to us by the nature of its flora, which was sub-tropical, and its fauna, which included such animals as elephants, rhinoceroses, hippopotamuses, hyænas, saber-toothed tigers, apes. But towards its close the climate became much more severe, and we find that herds of reindeers wandered southwards as far as the Riviera and Switzerland, and that arctic shellfish found their way into European seas. Colder and colder grew the earth; further and further south came the ice, till England was a mass of glaciers, and an ice-sheet stretched between England and the Continent. Down from the mountains of Norway crept the ice and snow. Now Russia was buried under it, now northern Germany, now northern France. In Switzerland colossal glaciers filled the mountain valleys and flowed across the plains. The Rhône glacier invaded France, and from the southern side of the Alps huge glaciers descended upon Italy, leaving mighty moraines on the plains of Lombardy.

BURDEN BORNE BY THE SOLID STREAM

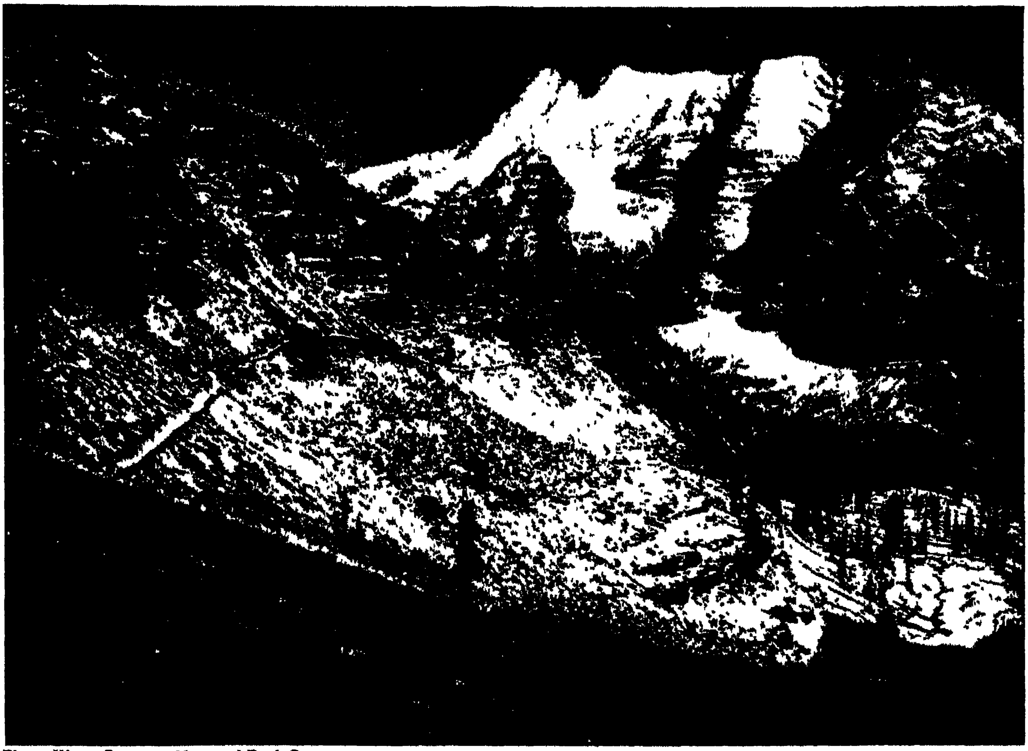


Photo Kiser, Courtesy National Park Service

THE ROCK-LADEN STREAM OF SNOW AND ICE. MOUNT JACKSON, GLACIER NATIONAL PARK

MEDIAN MORAINE AT THE JUNCTION OF THE GORNER, BREITHORN AND LYSKAMM GLACIERS

The Pyrenees, Apennines, Carpathians, Balkans, Urals, the Caucasus, even the Atlas Mountains and those of the island of Corsica, were heavy with glaciers According to Dr. Hooker, the famous cedars of Lebanon grow on the moraines of former glaciers. Asia had not quite her share of the snow and ice, but Siberia was icebound; glaciers descended from the northern Urals to the plains of Obi, and the Himalayas must have been white almost to their base. In North America the ice extended into the United States as far south as southern Illinois and New Jersey, while, strangely enough, Alaska escaped. Altogether, an area of 4,000,000 square miles was under an ice-sheet, chiefly the plains of Canada and the upper Mississippi valley Even tropical lands had to face an Ice Age. The snow-line crept thousands of feet down their high mountains; and mountains that had never known snow were capped with ice and burdened with glaciers. In the southern hemisphere the glacial epoch was less severe. Still, Patagonia, New Zealand, Australia, Tasmania, all had some experience of it.

THE FINDEL GLACIER FORMING A LAKE, WITHIN VIEW OF THE MATTERHORN AND RIFFELHORN

We have spoken of the Ice Age, but the Ice Age was not continuous: it probably consisted of several glacial periods, with intervals of milder climate, when the ice retreated from the boulder clay and vegetation flourished.

If we examine a thick deposit of boulder clay, we find that it is not homogeneous, but that there are layers of finer clay and sand through it, and in these layers often remains of animals and trees. The natural inference is that these layers represent a time when the ice retreated from the earth and thus rendered it again habitable. Professor James Geikie, who made a special study of the Ice Age, was of the opinion that in Europe there were several alternations of glacial period and more temperate periods. After the first glacial period, there came a great thaw and very genial climatic conditions The climate of Europe, indeed, though not so warm as in the Tertiary Epoch, was warmer than now, and over England there roamed elephants, rhinoceroses, and hippopotamuses. For thousands of years there was this period of genial warmth, and then again came the snow and ice, with a consequent change in the fauna and flora Icebergs drifted as far as the Azores, and arctic species of mollusks flourished round the coasts of Sicily and Italy Again a thaw. At first the boggy land grew only lichen and moss and coarse grass, and the fauna consisted of reindeer, woolly rhinoceroses, musk-ox and gluttons, but by and by, as a good climate persisted, the vegetation became more luxuriant, and elephants, deer, lions and leopards appeared.

Gradually again the climate changed, gradually arctic flora and fauna reappeared, and a third glacial epoch set in. This was not quite so rigorous as the second, but still Britain and a great part of northern Europe were buried under ice. In time a third inter-glacial epoch followed, but this time no elephants and hippopotamuses appeared, and the dominant feature of the vegetation was widespread forest. Still a fourth glacial epoch followed, to be succeeded by a fourth inter-glacial period, characterized, like the third, by a great growth of forests. Not even yet was the climate settled; a fifth glacial period supervened, and there were various climatic oscillations before the conditions that now prevail were established.

GLACIERS THAT CREEP FROM MONT BLANC

MONT BLANC, THE HEAD AND SOURCE OF THE MER DE GLACE

THE END OF THE GLACIER DES BOSSONS, SHOWING ITS TERMINAL MORAINE

In America there were at least as many oscillations of heat and cold. During the whole glacial period there were various submergences and emergences of the land. When the ice invasion was most extensive, it is probable that the northern parts of Europe and of North America were much more elevated than now. Arctic shells that live at a depth of 30 to 90 feet have been found 1330 fathoms deep in the clay of the North Atlantic, which would seem indubitably to indicate that the northwest of Europe must have once stood about 7000 or 8000 feet higher than now, and that a tremendous subsidence took place in the northern hemisphere after the time of maximum glaciation.

From this subsidence the northern hemisphere never quite recovered, but marine shells found in Wales at a height of over 1200 feet, in the Scotch hills at a height of 500 feet, and in the valley of the Saskatchewan at a height of 1900 feet, show that reëmergence of the land did to some extent take place. The cause of the fall and rise is uncertain. Some attribute the submersion to the weight of the ice, and the emergence to the removal of the weight by the melting of the ice, but it is more likely that there were movements in the earth's crust quite apart from ice pressure.

In the caves of France and some other parts of Europe human bones and hand-made implements have been found mingled with the bones of animals which were plentiful there during the glacial or interglacial periods. It is uncertain, however, whether man had reached America as early as the last glacial advance, for there is no evidence of human bones or implements among the remains of the extinct animals of American glacial times.

The cause of the Ice Age is unknown. About twenty years ago, James Croll endeavored to show that it was due mainly to the indirect effects of an increased eccentricity of the earth's axis. With the sun farther away from the earth in winter, he thought that a colder and snowier winter would ensue in temperate latitudes, and that the winter snow would persist through the summer, and give rise to fogs which would intercept the summer sun. The trade winds and the ocean currents would consequently be altered, and the cumulative effect would be a genial epoch alternately in the northern and southern hemisphere. This theory did not stand the test of critical examination, and it is now almost completely given up by expert geologists.

Attempts have also been made by Chamberlin and Arrhenius to explain the glacial epoch on the basis of variations in the amount of carbon dioxide in the atmosphere. A little more or a little less carbon dioxide, by diminishing or increasing radiation of heat, would have important climatic consequences, but it is not certain that this alteration would be competent by itself to produce the glacial periods Still a third attempt has been made to explain the Ice Age on the basis of geographical changes such as elevation of a vast area of land, with deflection of warm air and warm ocean currents. No doubt such geographical changes would produce climatic alterations, but the theory is still quite unproved. Altogether we must confess that no adequate scientific explanation of the Ice Age has yet been found.

It may be noted here that the great Ice Age of which we have been speaking is not a unique occurrence in the earth's history, for in the strata of earlier geological ages are found striæ, roches moutonnées and glacial boulders, giving clear evidence of the existence of a glacial epoch in the southern hemisphere during the Permian Period at the end of the remote Palæozoic Era.

MAN'S MOST DEADLY ENEMY

The War that is Being Waged between Mankind and the Tubercle Bacillus

A GREAT DISCOVERER'S MISTAKE

OF all parasites whatever, the most deadly is the tubercle bacillus, or *bacillus tuberculosis*, which was discovered in 1882, in Berlin, by Robert Koch, the greatest of Pasteur's followers in the realm of pure bacteriology. For long there had been no doubt that such a microbe must exist, and Koch had been searching for it for eleven years; but not until he devised a special technique, by which the microbe can be stained, and made visible, was he at last rewarded. Man is thus at last face to face with his greatest enemy in the living world, for this bacillus takes the life of about one-eighth of all mankind; and his first duty is to learn as much as possible about the foe he has to fight.

The facts are very remarkable, and they raise questions which we cannot answer as yet, but answers to which are necessary if we are ever to fulfil the prophecy of Pasteur, and make this parasitic disease disappear from the earth. In the expectoration from cases of consumption, in the degenerate substances of tuberculous joints and elsewhere in the invaded body of man, we find this tiny fungus, a very slender rod, about one-24,000th of an inch in length. Its causal relation to the disease has long been proved, on the lines already discussed. But we find that, in many instances, animals suffer from tuberculosis which we have not experimentally induced In fact, this is not a parasite of man alone. On the contrary, it can produce tuberculosis in apes, cattle, birds, fish and many other animals, and we find it occurring in these creatures in all parts of the world.

Sometimes we infect them; very often they pass on the infection to us — in milk. as a rule, in meat occasionally, or possibly. This adaptability and wide distribution of the bacillus constitute a formidable difficulty. It is almost, if not quite, as competent, hardy, widespread, pertinacious an inhabitant of this planet as man himself. To deal with it radically can be no easy task. Microbes exist which apparently can live upon the body of man, and nowhere else Their race is maintained in the world only by passage from man to man; and if this be arrested they must die out. Such would appear to be the case with the bacillus of leprosy, which is remarkably similar in microscopic appearance to the tubercle bacillus. Thus, if we isolate lepers, as our ancestors effectively did many centuries ago, there is an end of the disease. It attacks no other living creature, so far as we know.

But here we are faced with a parasite which attacks a variety of forms of animal life; and, if we are to win in the long struggle for existence between this parasite and our own species, we must learn the whole of its life history. In the forty years during which we have known this parasite, much has been learned. With a fairly accurate idea of its distribution in the animal world, we know that it can be transferred from one animal to another, of the same or of another species. We know that it can live for a time in dust, dirt and darkness. We know, also, that it varies a good deal according to the particular species in which we find it.

Thus man is really subject to two distinct forms of tuberculosis, of which we call one human and the other bovine That is to say, in certain cases, the bacilli which we obtain from a human being suffering from tuberculosis belong to a type which is more commonly found in man, and is not normally found in bovine animals. This we call the human form of the bacillus; and we conclude that it has been derived from another human being. But in other cases, which cannot be distinguished by the doctor as belonging to a different type, we find that the bacilli, when cultivated outside the body, show the characters which we associate with the bacilli usually obtained from bovine animals, and found, for instance, in about one-tenth of all the samples of milk supplied to our cities

Such is the nature of the problem, as we have only very recently ascertained — so recently that it is very important to state the facts here at the very beginning of our discussion. Continuing his work upon the bacillus which he had discovered, Koch found not merely that it was responsible for similar kinds of disease in a variety of animals besides man, but also that its type varies in these different cases, and that, after long culture in the laboratory, on various media, one can still definitely declare one growth to be that of the human and another of the bovine bacillus. Naturally, the question arose as to the interchangeableness of these two types — the others, avian, piscine, etc , do not practically concern man Koch made some experiments, and reached the conclusion that the *bovine bacillus is innocuous to man.*

Koch's surprising announcement of man's immunity to the bovine bacillus

This conclusion he announced before the International Congress on Tuberculosis when it met in London in 1901; and of course the announcement, coming from the discoverer of the bacillus and the greatest bacteriologist then living, made a great sensation.

Its practical importance was obvious. If man is immune to the bovine type of the tubercle bacillus, we need worry no more about the presence of bacilli of that type in tuberculous milk and meat. All our precautions regarding the slaughter of tuberculous cattle, the detection of tuberculous milk due to tuberculosis of the udder, or the pasteurization or sterilization, by other means, of suspected milk, are superfluous. All that department of the supposed prevention of tuberculosis may be ignored, and we must concentrate entirely upon other aspects of the problem But Koch's conclusion was so surprising, it raised so many new problems — for instance, as to the source of the bacilli which so often invade the bowels of children — and it depended on so small a measure of evidence, that it could not possibly be accepted as final A warning note was sounded at the meeting itself by Lord Lister, and a commission was appointed to reexamine the whole question.

The proof under reexamination of Koch's tragic mistake

After a period of several years its final conclusions were published We now have the advantage of those conclusions, which are generally accepted, and we have to look at the whole problem of tuberculosis in the light of them In a word, Koch was wrong He was a great genius in his way, but always a hasty one, and he had been tragically wrong, on a former occasion, with a "tuberculin" which was to cure consumption, but failed to do so. In the later case he was undoubtedly right in pointing to the difference between the two important types of tubercle bacillus. All that was valuable work, and the fruit of it will yet be gathered. The distinction he discovered is a real one; and we are definitely a step nearer the conquest of tuberculosis because Koch has enabled us to trace the origin of the infection in the various types of cases that we study, for plainly the first step towards arresting the infection is to know its origin But he was unfortunately wrong in his assertion that man need not fear the bovine form of the tubercle bacillus Our problem would be almost incalculably simpler had he been right. It would probably be no more, in essence, than that of leprosy, which our ancestors solved.

We have to face the fact, however, that the bovine species, upon which we are so largely dependent, is a huge living reservoir of the tubercle bacillus, which is constantly passing from it to ourselves. Thus it follows, from the results definitely obtained by the commission, that even if we could discover and isolate every human being now infected with tuberculosis the disease would still continue — no doubt immensely reduced in amount, but widely prevalent nevertheless

DR. ROBERT KOCH IN HIS LABORATORY

There is the gravity of the problem. In the case of leprosy, or of syphilis, or of many other diseases, one course of action, the simple separation of the sick and the sound, will, if thoroughly carried out, shortly abolish the disease; or such is the presumption, if the parasites in question do not come freshly into existence in any unknown ways. But here we require to protect the sound not merely from the sick of their own species, but also from the sick of another and indispensable species. And various obscure problems now face us. Let us for the present take it for granted that the bacillus may pass from one human being to another, or from, say, cows' milk to a human being. We then have it clearly understood that a human being may get the bacillus from one of two known sources, and not otherwise. That, of course, is most important knowledge, not to be underrated. Our predecessors thought that consumption was a kind of degeneration of the tissues, probably of hereditary origin, pathetic, inevitable, uncontrollable. On the contrary, we believe that it is an infection derived from one or other of two known sources, and impossible of occurrence without that infection. We know, further, that the new-born infant is free from tuberculosis. Once in *millions* of cases we find exceptions to this rule, but they are among the rarest of pathological curiosities, and need not concern us further. The rule is that, though the mother be rapidly dying of the disease, as many an expectant mother is today, the unborn infant is completely protected, thanks to

the filtering action of the placenta, the organ by which it comes into relation with the maternal blood. Hence, though child-bearing almost invariably hastens the development of consumption, the practically invariable rule is that the infant is born free from any tubercle bacilli. For practical purposes the initial fact is that we all come into the world free from the infection which will ultimately kill one in eight of us. And that infection, as we have seen, can be definitely traced to one of two sources.

The gravity of the problem of infectious animal disease

But the fact that there is a bovine source introduces the question of bovine infection. The calf is born, as we are, free from the tubercle bacillus, but somehow acquires the infection If we could interfere with that infection we should strike at one of the two roots of human tuberculosis, and would be left with a relatively simple problem. The trouble is that we do not yet know the life-history of the tubercle bacillus. We find it in cows and men, and in places which they have frequented, but we do not know its original source. The question of the source from which the cow derives it has not yet been seriously raised. We have simply taken it as the fact that the cow is liable to be infected, as we are, but we have not asked and answered for the cow the questions we have asked and answered for ourselves, nor do they look as if they could easily be answered. It can be readily proved that man gets the bacillus in cows' milk. No doubt calves are similarly infected by their mothers, and indeed good work has been done in separating calves from tuberculous cows, and thus obtaining herds free from tubercle. This is exactly parallel to the separation of infants from tuberculous parents. But the question arises whether such measures, rigorously carried out, would extirpate bovine tuberculosis, as segregation extirpated leprosy in man. It may be that they would not, because there may be some reservoir in nature from which bovine animals can derive the bacillus. This is by no means improbable, though unfortunately we know as yet nothing about it.

The possible evolution of new forms of harmful bacilli

Dr Henry Charlton Bastian and a few others have long warned men of science that they take too many things for granted regarding the bacteria. We are apt to label one kind "pathogenic" and another "non-pathogenic", and to assume that they have been so from the beginning, and will always be so. We talk a great deal about evolution, but we do not allow for evolution among the bacteria, though it must obtain there as it does everywhere else It may be that the tubercle bacillus is a modification, or a descendant, or an adaptation, or a domestic form, so to speak, of some other microbe, itself non-pathogenic, which has a wide distribution in nature. Under favorable conditions, especially the close aggregation of human beings or bovine animals in dark, dirty, ill-ventilated places, it may be that some ubiquitous bacillus takes "pathogenic action", and becomes the tubercle bacillus we find in so many of the higher mammals under these conditions.

The species we call the tubercle bacillus must have had an origin somehow; and its origin can scarcely have been other than from a non-pathogenic form which found special opportunities for the extension and multiplication of its life in the bodies of certain animals under certain conditions In the terminology which we have already observed, a saprophytic organism has become parasitic We really require to search, therefore, for the natural ancestor of the tubercle bacillus, or the form, perhaps abundant, from which the tubercle bacillus can be derived under the conditions just described.

The double task of rescuing man and the cow from tuberculosis

Meanwhile, we see clearly that the problem of mastering tuberculosis cannot be achieved by man unless he at the same time achieves it for the bovine species. He must undertake this double task. The only alternative would be to abandon all use of the bovine animal as food, or, at any rate, of its milk. We can easily enough protect ourselves against tuberculous beef, and

might not be compelled to abandon all beef, but could we give up cows' milk? This could be done only by having recourse to the milk of some other mammal not commonly affected by tuberculosis. Such an animal, it has been supposed, is the goat; but the immunity of the goat from attack remains unproved, and does not warrant any such drastic proposal as the rejection of the cow.

The impossibility of substituting the goat for the cow as a milk producer

Man, and the ox, do not suffer from tuberculosis under conditions of open air and light, in which the tubercle bacillus cannot thrive; nor do we find tuberculosis in the anthropoid apes in their own forests. But when man proceeds to live, or makes the cow or the ape live, under conditions which favor the bacillus, tuberculosis ensues. If we began to use goats' milk, the chances are at least very considerable that the enormous aggregation of goats which would be required, and the conditions under which they would be made to live, would quickly increase tuberculosis among them, whether because the resistance of the animals would be lowered, or because the bacillus can thrive, and perhaps takes its origin from other forms of life, under conditions of dirt and darkness. We already know that the goat is by no means immune from bacterial disease, for what is known as Malta or Mediterranean fever is due to a microbe which is distributed to man with the milk of infected goats. It is in the highest degree probable that, under the conditions which would soon be imposed if all our milk and dairy produce were to come from the goat, we should soon find it distributing the tubercle bacillus, as it now distributes the coccus of Malta fever.

If we wished to keep our goats free from the disease we should almost certainly find it necessary to provide them with hygienic conditions of life, and that is, in fact, what we may just as well proceed to do at once for our cows. No real alternative offers itself. Whether for the human or for the bovine species, the necessity is really the same — conditions of life must be provided in which the tubercle bacillus does not thrive. Though we do not know the natural source of the bacillus, we know a great deal about its mode of life. It likes dirt and darkness, and cannot face the sun Unhygienic aggregations of the higher animals, in artificial dwellings which exclude the light, are its opportunity. Once, therefore, certain facts have been established, we have no choice as to our procedure. Those facts are that mankind is constantly being infected from the cow, so that the complete segregation of infected human beings will not abolish the disease, and that there is no probability of any better state of things if man goes elsewhere for the milk and milk products which are absolutely necessary for him. He must therefore either use no uncooked cows' milk, nor any product of unsterilized milk, such as butter — which is, on the whole, an impossible or deplorable alternative — or *he must abolish bovine tuberculosis.*

That is the practical conclusion to which we are forced. Even the liberal and persistent expenditure of unlimited sums of money will not abolish human tuberculosis, unless they are spent rightly, so long as we continue to use cows' milk and its products. But, though as yet we do not understand the process of bovine infection, bovine tuberculosis can in effect be controlled, if we apply to it the same principles which are effective when applied to ourselves. The interests of the two species, bovine and human, must be regarded as one, and we must proceed with the bovine population as we mean to proceed with the human population.

The need for diagnosing concealed tuberculosis in the cow

The Danes have shown that herds free from tuberculosis can be obtained. This is the first essential; as in the case of every other infection, the sick must be separated from the sound. The calves are born uninfected, as we ourselves are; and that clearly gives a starting-point. The adults must be sorted out; and here the importance of exact diagnosis is evident, as in the case of mankind. With such a disease as this, rough-and-ready methods are useless.

They are not cheaper, even, for they fail to achieve the economic end. Anyone can detect advanced tuberculosis of the udder of the cow, but that is not enough The Tuberculosis Commission ascertained the extremely unsatisfactory fact that the cow is liable to rid herself of tubercle bacilli by means of her milk, though the udder may be unaffected. Thus tuberculosis in any part of the cow's body may lead to the infection of the milk; and the necessity is imposed upon us of detecting concealed tuberculosis, which may perhaps be producing no obvious symptoms at all Here we are greatly helped by Koch's researches, and the various forms of "tuberculin". Though these products of the tubercle bacillus were disappointing therapeutically, and require much improvement before they will do all we need for the cure of patients, they are very valuable in diagnosis.

Koch's discoveries a test, though not a cure, for tuberculosis

It is now possible, by means of the developments from Koch's work, to test a cow or a human being, and ascertain by the reaction whether the individual is suffering from tuberculosis or not. When we remember what proportion of samples of milk contain living tubercle bacilli, we shall not be surprised to learn what an enormous proportion of cows give a positive reaction when the tuberculin test is applied But the fact has to be faced The milk of such cows is not fit for human consumption, and such cows are a source of danger to healthy ones. Their calves should be removed from them directly they are born; and new herds must be composed of animals which are pronounced free from tuberculosis after the application of the tuberculin test.

Of course, this is a very serious and expensive business, but we can only reply that human tuberculosis is more serious and expensive still. There is more to follow. Supposing that we have at last obtained a stock that is free from tuberculosis, we still have to maintain it so. Many bacteriologists and veterinarians are inclined to assume that the stock can be maintained free from tuberculosis, provided that no tuberculous animals be introduced, just as a human stock can be kept free from leprosy on a similar condition But this is far from being proved As we have tried to insist, nothing is yet known as to the natural origin and natural habitat of the tubercle bacillus At all times, some widely distributed saprophytic bacillus may be liable to undergo an evolution into what we call the tubercle bacillus, in certain conditions which we are only too apt to provide for cattle and for ourselves If that be so, we can maintain the freedom from tuberculosis of the stock we have obtained only by providing it with hygienic conditions.

The provision of hygienic conditions the only safeguard

In fact, that is the experience The disease will somehow appear unless we take care, and that can be done only by keeping our stock in those conditions in which the tubercle bacillus cannot thrive This is, of course, an expensive affair, and there is no end to it, but the only alternative — the use of goats' milk — would probably be found, as we have suggested, to involve just the same requirements.

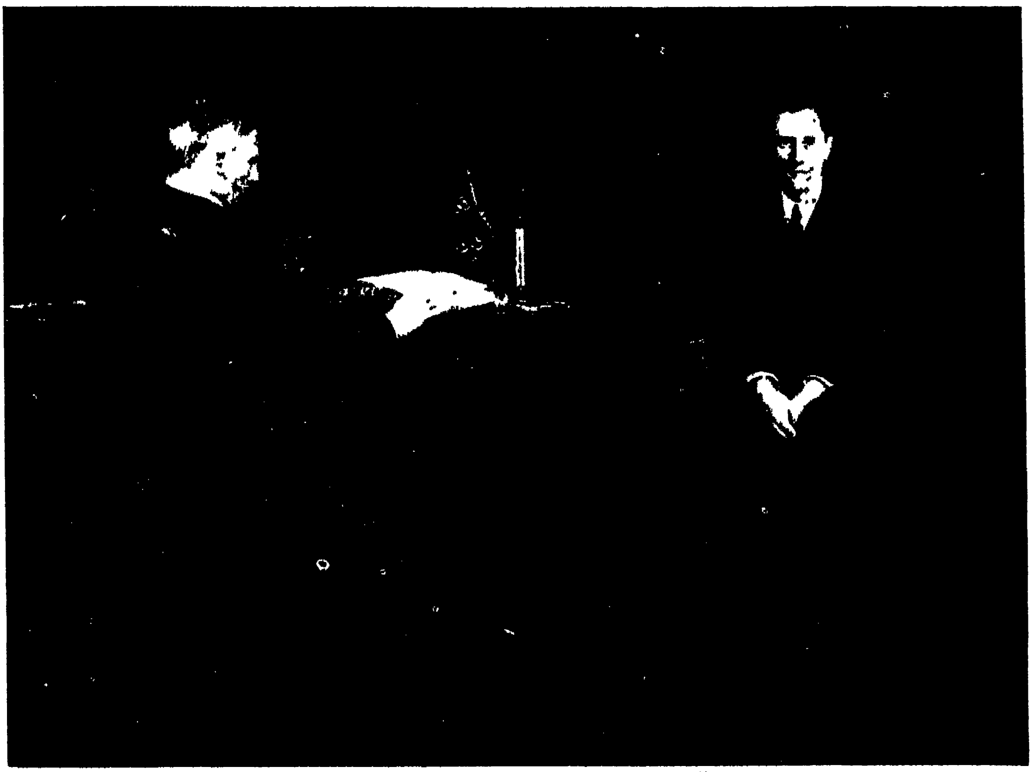
The principles of organic evolution may afford us some guidance here Should there not be a process of adaptation, dependent upon natural selection, by which we could breed a race of cattle, or of men, which should be immune to the tubercle bacillus? Then we need no longer trouble about the difficult task of exterminating a creature which may be hydra-headed, always liable to a fresh genesis under suitable conditions; and we might also save all the expense of sanitation and cleanliness and the supply of light, because our population would now be able to resist the tubercle bacillus, however abundantly it might continue to flourish under such conditions.

This is an argument which must be very carefully studied. There is no doubt that the natural susceptibility of various animals and men to the inroads of this bacillus varies greatly. Just as a wheat can be developed which is immune to rust, why should not we be able somehow to produce

races of cattle or men which are similarly immune to tuberculosis? Or may it be that organic evolution, and the stern discipline of natural selection, with the destruction of the susceptible, must be invoked? And if that be so, ought we not to encourage the spread of infection, and the conditions which favor it, so that, as soon as possible, the susceptible may be removed and an immune race produced?

Such is the argument advanced, in the name of Darwinism, against modern measures for dealing with this disease. Its champions appeal to biological principles. They rightly point out, as we have tried to insist, that our modern study of disease must be biological; that this is simply a special case of the struggle for existence between two species; and they argue that it involves a selective action, whereby the most resistant will survive So that all attempts to interfere with the disease will simply mean, in so far as they are successful, that we shall produce a race which will be more liable to it than if the susceptible had been killed off, and human susceptibility had disappeared with them.

The fact that real differences in susceptibility exist cannot be questioned. They are largely racial, and they do seem to correspond very largely to the argument of the Darwinians. Thus it has long been known that negroes, when brought into the cities of temperate climes, are extremely liable to tuberculosis Their death-rate from this disease in the United States is enormous, and the same has been observed everywhere This may be explained, we suppose, at first sight, on the ground that the negro is accustomed to the warm climate of the tropics, and that the cold of the temperate zones lowers his resistance to the tubercle bacillus which so much abounds in our cities. But a complementary observation has lately been made which disposes of this argument. The appalling susceptibility of the negro to tuberculosis is exactly matched by that of



THE WHITE SCOURGE, AS TYPIFIED IN "THE SENTENCE OF DEATH," BY THE HON. JOHN COLLIER

the Eskimo. Practically every Eskimo, without exception, who has been brought into the cities of the North Temperate Zone has sooner or later — but sooner, rather than later — succumbed to tuberculosis. We think of the Arctic regions as bitterly cold, and therefore liable to give one "colds" and bronchitis and consumption. But the fact is that the microbes of these maladies do not thrive there, and hence they are unknown. The Eskimo comes south from his frozen home, and the negro comes north from his torrid home, neither of them having been racially accustomed to tuberculosis, and they fall prompt victims.

Those are the facts. Here we neither reject nor accept the Darwinian interpretation of them, which is quite another question It is obvious that members of these races, placed in a strange and complicated environment, and subjected to novel temptations, may lower their resistance, notably by alcoholism, to a degree which would render any racial theory of their susceptibility superfluous. For the moment we will not argue this question But there are many more facts besides these

The extraordinary immunity of the Jewish race from consumption

For instance, the Darwinian school may very reasonably point to the astonishing immunity of the Jews from consumption, even in the worst quarters of our cities, and may argue that this is the fruit of long ages of natural selection. The ancestors of modern Jews have been an urban people, confined to the ghetto, for very many generations. In other words, on this theory they have been rigorously exposed to stringent selection by the tubercle bacillus If we could have access to records of the past, we should find that they suffered accordingly, but that the ancestral suffering has led to the formation of a race which is very nearly immune to this enemy. And the argument, then, is that only by similar means can the Gentile hope to defeat the same enemy.

Here, again, we place on record the fact, evidently important and, indeed, unique. But we do not accept this interpretation of it as final. We need only remind ourselves of the extreme temperance of the Jewish people in regard to alcohol, and the rigorous precautions which they take in regard to, at any rate, some forms of tuberculous infection. The Jew, who will touch none but "Kosher" meat, is at least safe in that respect.

A type of people who can kill the bacillus for themselves

As regards these facts of racial susceptibility to, or immunity from, tuberculosis, we can only say that they are very remarkable, and that we want to know a great deal more about them. Certainly they must have great lessons for us, which we shall some day be able to define exactly. But also within the limits of a race notable differences occur. When we survey the whole range of patients suffering from tuberculosis in almost any city or town, we find that, broadly, two great types can be recognized. The number of intermediates will always predominate, and the gradation is continuous throughout, but patients from the opposite ends of the scale are unmistakably to be contrasted. The one type has acquired the disease owing to conditions which are, in the main, external and accidental.

It is only purely by chance that they are there at all, instead of being in the company of those who have never knowingly suffered from tuberculosis. They may have been exceptionally and persistently exposed to very virulent infection. They have been run down by measles, whooping cough, influenza or some other infection, and, while in this exceptionally and unnaturally feeble state, the tubercle bacillus has taken hold of them. Or they have been overworked and underfed in conditions of darkness, dirt, foul air and so forth.

Patients belonging to this type cannot be distinguished by looking at them. They are not predominantly dark or fair, so far as we know yet, nor of any other particular physical type. But we know them by the way in which they react to improved conditions and to treatment generally.

A type of people who are killed by the bacillus

The mark of them is that, under anything like fair conditions, they put up a strong natural resistance. Under such conditions they recover, and that is the proof of their quality. But patients from the other end of the scale do not recover. They may or may not have been exposed to bad conditions, but when they are placed in good ones, they do not respond. They are incapable of putting up an adequate resistance to the tubercle bacillus; and until the time comes when we can kill the bacillus for them and in them, by some special substance contrived for the purpose, such patients will die. They cannot kill the bacillus for themselves, but the other type of patients can.

Now, say the Darwinians, this is simply an illustration of well-known evolutionary principles. The race is undergoing evolution against this disease, just as the Jews, with their long residence in cities, have already undergone it. The differences between these two extreme types of persons are native, natural, transmissible. Therefore the only conceivable way of abolishing tuberculosis is by the natural way of abolishing persons liable to become tuberculous. They must be weeded out, together with the offspring, like themselves, whom they would otherwise have had, and so an immune race will be produced. Here, again, we do our duty of placing on record the facts of contrast within the limits of a race, together with the facts of contrast between different races. But very much work of discrimination has yet to be done before the Darwinian argument can be accepted, and tuberculosis be relegated to the attention of Eugenists.

A NECESSITY FOR EVERY DAIRY OF TODAY — THE LABORATORY FOR THE TESTING OF MILK

The fact must be accepted that, in adolescence, and even before it, clinical observers can detect two contrasted types of patient, with two very different prospects of recovery. But it by no means necessarily follows that these differences are natural. There is the factor of early nurture to consider; and even if the defective resistance be natural, we may find that it is *unnaturally* natural — due, perhaps, to the damage caused in the germ-plasm by parental tuberculosis (which is a blood-poisoning) or parental alcoholism.

But until these possibilities have been excluded, and until we have definite evidence as, for instance, to the subsequent incidence of tuberculosis in breast-fed and not-breast-fed infants, we have no right to assume that the differences in resistance, observed in later life, depend upon what the Darwinians call "spontaneous variation", and can be dealt with only by allowing the tubercle bacillus to identify for us all those who cannot resist it, and then seeing to it that they produce no children

A MODERN SANATORIUM, WHERE SUNLIGHT AND FRESH AIR REPAIR THE RAVAGES OF A FELL DISEASE

What we require now is a rigorous analysis of the factors of the problem. The disease is an infection, and therefore we must learn all we can about the infective agent, its variations in virulence, the dosage of infection, the effect of repeated infection, the routes of infection, and so forth, it being assumed that every case of tuberculosis has involved efficient infection, which might have been prevented, as in the case of the highly susceptible Eskimo, who is quite free from the disease in his own country. Secondly, we have to study susceptibility; and from the point of view of practice and of prophecy, from the standpoint of the physician and of the biologist alike, we must undertake a piece of analysis for which we are still waiting.

We must somehow distinguish between genetic and somatic, inherited and acquired, susceptibility to this disease. If we find that the genetic factor is cardinal and preponderant, we must hand over the problem of tuberculosis to the Eugenists, for nothing we can do will solve it, short of the extermination of the bacillus, which is a large order, as we now see. But if and until the genetic factor in susceptibility is so appraised, we must deal with the somatic factor, the existence of which is indisputable; and we shall find that great things are already possible.

INSECT ENEMIES OF FRUIT CROPS

Attacks upon the Apple, Pear, Plum, Cherry, Peach, Grape and Raspberry

MOST APPROVED METHODS OF DEFENSE

NO account of the enemies of plants would be at all satisfactory which did not include a discussion of the various kinds of insect pests that infest our orchards and attack our different varieties of fruits. There are many kinds of these pests that injure fruits and they cause very great losses each year. It is no uncommon thing to find the crop of a certain kind of fruit almost ruined as the result of an attack of some insect, and there is scarcely an orchard or garden in this country that does not suffer more or less injury every year from some one or more of these pests. It has been estimated that the various insect pests in this country which attack the deciduous fruits, such as the apple, pear, plum and the like, cause an annual loss of over $66,000,000. It is impossible to discuss each of the insects that are responsible for this great amount of damage, and we shall have to be content with an account of the life history and habits of a few of the better known and more injurious ones, together with a consideration of the most approved methods of preventing their ravages.

One of the oldest, best known and at the same time most destructive apple pests is the codling moth, which also attacks the pear and quince. An authority on this insect estimates that it causes a loss of over $16,000,000 each year to the fruit growers of this country, to say nothing of its ravages in Europe and other apple-producing countries where it is also found.

The moth is a small gray one, measuring only about ¾ of an inch in width when its wings are fully expanded, as shown in Figure 1 on the next page. The moths appear in the spring about the time or very soon after the apples blossom, and in a few days begin to lay their tiny white eggs on the leaves, branches and later on the young apples. In a week to ten days the eggs hatch, and the small caterpillars find their way to the young apples, which they enter mostly through the blossom ends. The caterpillar lives within the apple for about one month and burrows through the pulp of the fruit, eating the seeds and causing the apple to fall, or if it remains on the tree, greatly injuring it by the cavities eaten out of the inside (Fig. 2). When the caterpillar has become full grown, it is pinkish white in color and about ¾ of an inch in length. About this time the caterpillar makes a burrow to the exterior of the apple and when full grown leaves the fruit and crawls down the trunk of the tree, where it hides beneath a loose piece of bark, spins a cocoon, and either changes to a quiet object called a pupa, or simply rests in its retreat without any change until the following spring. Those caterpillars that spin cocoons and change to pupæ remain in this condition about ten days and then transform to the handsome gray moths that deposit their tiny eggs for a second generation of caterpillars or "worms", as they are usually called. In some parts of this country where the seasons are warm and long there are three or four generations of the codling moth each year. The caterpillars of the last generation pass the winter in their snug retreats and transform to pupæ at the advent of warm weather, and in three or four weeks the pupæ transform to the moths, thus completing the yearly life cycle.

The codling moth has many natural enemies that aid greatly in holding it in check. The eggs and the caterpillars are destroyed by tiny parasites, at least seven having been found to attack the caterpillars. If it were not for parasitic insects, our orchards and gardens would be literally destroyed in spite of all we could

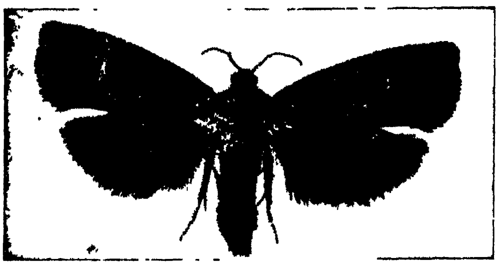


FIG. 1. CODLING MOTH
(enlarged three times)

do. In addition to the work of the parasites, the caterpillars and pupæ of the codling moth are destroyed in great numbers by different kinds of birds. In fact, there are over a dozen birds that are known to feed on this pest, and they constitute the most effective natural enemies of the codling moth. The nuthatches, chickadees and downy woodpeckers search

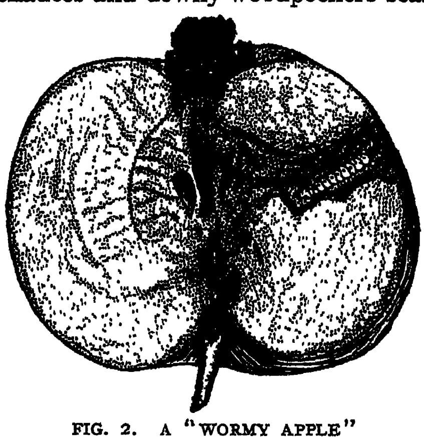


FIG. 2. A "WORMY APPLE"
Caused by the larva of the codling moth.

out the caterpillars in their hiding places beneath loose pieces of bark and devour them. These birds are so efficient in controlling the codling moth that special pains ought to be taken to attract them to our orchards. Pieces of suet tied to the branches will attract the birds and induce them to remain and nest among the trees. But in spite of all these natural enemies, the codling moth is the most destructive insect enemy of apples, and the severity of its injuries and the great losses caused by it emphasize the necessity of taking effective methods of artificial control.

Fortunately, an effective method has been found for the control of the codling moth. In this country nearly every progressive apple grower sprays his orchard at least twice every season and by so doing protects his crop of apples from becoming wormy and unfit for market. As soon as three-fourths or all of the blossoms have fallen the trees are sprayed with paste arsenate of lead at the rate of 5 pounds to 100 gallons of water. The young apples are just forming, and at this time they stand upright (Fig. 3) with the small brown leaves called the calyx at the blossom end spread wide open. Great care is taken at this time to put the spray mixture into the blossom end of the apple down in what is called the calyx cup, for it is here that the tiny caterpillar enters the apple and takes its first meal. In a few days the calyx cup closes tightly and it is too late to spray, but if the poison mixture has been sprayed into the open cup, it will remain there a long time awaiting, as it were, the coming of the tiny "worm". This is the most important spraying for the codling moth and should be done thoroughly and with great care. Since some of the caterpillars enter through the sides of the apples and therefore do not eat the poison placed in the blossom end, a second application of the poison is recommended about three weeks after the first one. Finally, many apple growers often make a third application in mid-summer to poison the caterpillars of the second brood.

Formerly, burlap bands were put around the trunks of apple trees to form places beneath which the caterpillars would crawl to spin their cocoons. By examining the bands now and then and crushing the caterpillars found beneath them many were destroyed. It is now known, however, that spraying is much more effective in killing the caterpillars, and burlap bands are seldom used.

The woolly aphis is a serious pest of the apple, especially in the warmer parts of this country and in England and Europe. Unlike the codling moth, however, it attacks the tree itself and on an infested tree the insects are usually present on the roots below ground as well as on the branches. The tiny aphids have the habit of secreting fine, white, waxy threads through pores in their bodies and when many of them are congregated in a group along a branch the twig appears to be covered with a white cottony growth (Fig. 4, number 3). If the cottony material is closely examined, the bluish bodies of the aphids will be found beneath it, each aphis with its tiny slender beak inserted into the bark for the purpose of sucking up the sap of the tree They delight in clustering about a wound made in cutting off a branch or in breaks in the bark. As a result of their presence in these situations, scars, enlargements and deformities of the branches are caused, and if the aphids are abundant enough, the foliage of the tree becomes sickly and pale yellow, while young trees that are badly infested at the roots are easily blown over by the wind because so many of the roots have become decayed and broken off.

FIG. 3. YOUNG APPLES
At the proper stage for spraying for the codling moth.

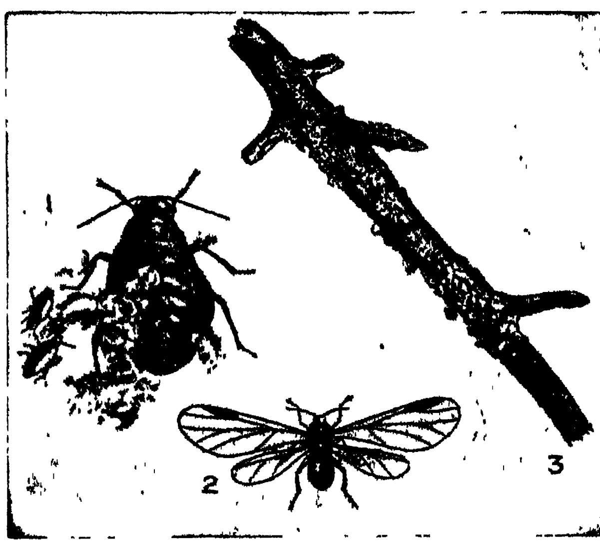


FIG 4. THE WOOLLY APHIS, OR APPLE-ROOT LOUSE
1, wingless viviparous female; 2, winged female; 3, apple twig covered by woolly aphids

The life history of the woolly aphis of the apple is not yet wholly understood. First it is to be noted that some of the aphids live above ground on the branches while others live below the surface on the roots of the tree. Those living below ground cause knots or galls on the roots and finally bring about their decay.

During the summer the wingless, cottony-covered aphids may be found on the branches and on the roots of infested trees. Generation after generation is produced during the warm season in these situations, but in autumn a wonderful thing happens. Suddenly a generation of aphids appears the individuals of which have wings and some of these fly or are blown to near-by elm trees. Here the true males and females are produced and each tiny, wingless female lays a single dark oval egg in the crevice of the bark on the elm tree. It is said that females are produced also on the apple tree and that eggs are also laid there. But it would seem that most of the eggs are laid on the elm as we have described. The eggs remain on the bark over the winter and hatch, in the spring, into wingless aphids which may be found on the buds of the elm. Here other aphids are born and in feeding on the leaves cause them to swell and curl. Bunches of infested elm leaves covered with white woolly aphids may easily be found in the spring on many elms. Later, a generation of winged aphids is produced and some fly back to the apple, where they reinfest the tree.

Fortunately, the woolly aphis is held in check by several enemies, among which are certain tiny parasites. The aphids are also devoured by the larvæ and adults of several species of ladybird beetles and by the larvæ of lace-wing flies and of certain true flies known as the "syrphus flies". Undoubtedly birds feed upon them and aid in holding them in check.

The aphids on the branches may be killed by spraying the tree thoroughly with a 15 per cent kerosene emulsion. This may be made by dissolving half a pound of soap in one gallon of water and adding two gallons of kerosene. While the

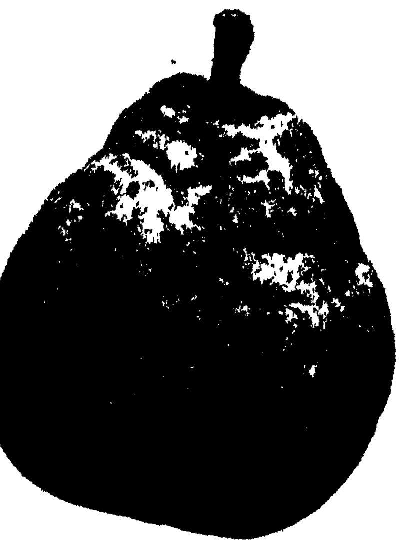


FIG 5. A PEAR BADLY INFESTED WITH THE SAN JOSÉ SCALE

water is quite hot the mixture should be thoroughly agitated until a white, creamy emulsion is formed This stock solution should then be diluted with $10\frac{1}{3}$ gallons of water to form a 15 per cent emulsion.

The aphids underground are much harder to destroy. In the first place one should not accept trees from the nursery which are infested with the woolly aphis. Considerable experimental success has been had in this country by soaking the soil around infested trees with a 15 per cent kerosene emulsion. The soil is first removed around the tree over a circular area of $1\frac{1}{2}$ to 4 feet in diameter, depending on the size of the tree, and to a depth of 3 inches. The soil is then soaked with the emulsion, 3 gallons on the smaller area and 6 gallons on the larger, after which the earth is replaced.

The San José scale, which would better be called the Chinese scale because it originally came from China, is another very serious pest of the apple in America, and it has also become established in Japan, Australia, Chili and Hawaii. European countries have so far been able to keep it out of their territories by rigid quarantine. It not only attacks the apple but is a very serious pest to the pear, peach, plum, prune, apricot and currant (Fig. 5). In fact, it thrives upon a great variety of fruit trees, shrubs, shade and forest trees.

It was first discovered in this country near San José, Cal., where it was probably introduced about 1870 on imported plants. It was first known to science and first given a name in 1880. Since that time, however, it has spread into nearly every state in the United States and has reached many sections in Canada. The San José scale attacks all parts of the tree above ground, and when abundant kills the infested plants. On badly infested trees, especially peach trees, the branches become completely covered by the tiny insects and appear as though enveloped in a grayish incrustation. Each female insect has a long, slender beak which she forces through the outer bark into the tender, sappy layers beneath and sucks up the nourishment from the tree.

Each tiny insect is covered with a small waxy scale, which in the case of the female is circular and about the size of a pinhead (Fig. 6). The body of the female is yellowish, and she has no legs or wings and consequently cannot move about after once becoming established beneath her waxy house. The male, after a short time, develops an elongated scale and becomes furnished with wings with which it can fly. Curiously enough, the male insect has no mouth parts fitted for taking food and does not live long after it becomes full-grown.

The insects pass the winter in a partly grown condition on the infested trees beneath their tiny, almost black, waxy scales (Fig. 7). In the spring the mother insects produce many young ones that crawl out from beneath the mother's scale and go in search of places where they can push their beaks into the bark and settle down for life. Each one looks like a minute, yellowish white mite at first, but after it settles down on the bark, it soon begins to form the waxy covering over its body and in a short time becomes entirely hidden beneath the scale. In about 45 days the young scale insects become full-grown and ready to produce another generation. During a single season there may be two or three generations, depending on the length of the summer; and since each mother scale is capable of producing from 100 to 500 young, a tree infested with a comparatively few scales in the spring may become fairly incrusted with them by the end of the season.

Although the San José scale insects are no longer than the head of an ordinary pin, yet there are at least nine species of wasp-like insects that are small enough to deposit their eggs in or on the bodies of them. Each tiny parasite finds food enough in the body of a scale insect to grow and become mature, and there can be no doubt but that these nine different parasites do very much good in destroying the San José scale. In addition, there are about a dozen ladybird beetles that prey upon this pest.

Finally certain fungous diseases attack the scale insects and cause their death. Despite this large array of natural enemies the San José scale has been one of the worst insect foes the fruit grower has ever had in America, and much time and money have been spent and are being spent in fighting it. The most effective way is by spraying the infested trees, either with some form of oil emulsion or, more generally, with what is known as the lime-sulphur wash, made by boiling a certain amount of lime and of sulphur in a given quantity of water for a definite length of time. When the boiling is completed a concentrated solution will result, which must be diluted before using by the addition of water. Even then it is so caustic that it can be applied only during the

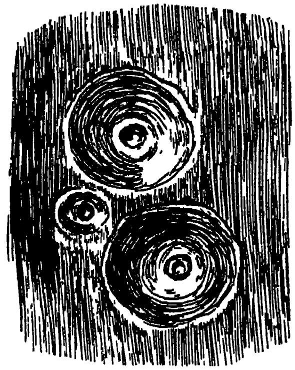


FIG 6. FEMALE SAN JOSÉ SCALE INSECTS (much enlarged)

FIG. 7. A BRANCH INFESTED WITH THE SAN JOSÉ SCALE

dormant season, either late in the autumn after the leaves have fallen or early in the spring before the buds have started. Splendid success has been obtained with the wash in America. In fact, the lime-sulphur wash has saved many an orchard in the United States from total destruction. It is applied with a strong force pump, in most cases nowadays with large power sprayers capable of maintaining a pressure of 150 pounds or more per square inch.

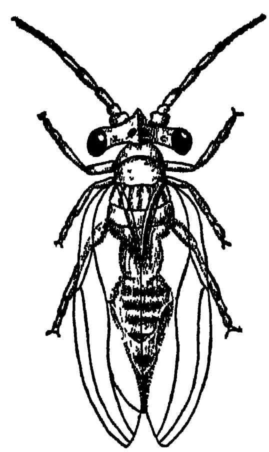


FIG. 8. AN ADULT PEAR PSYLLA (much enlarged)

The pear psylla is perhaps the chief pear insect pest in this country, especially in the East. It was introduced into the country from Europe probably about

1832 and has thriven here even more vigorously than in its native home. The fully grown psylla is only about $\frac{1}{10}$ of an inch in length. It is dark reddish brown in color and has four delicate thin wings, large eyes and two slender antennæ (Fig. 8). It has sucking mouth parts like the San José scale, and when multitudes of young psyllas are present they cause such a drain that the infested tree becomes sickly in appearance, the leaves turn brown and drop off in midsummer. The effect is such that the tree fails to make growth or to produce fruit buds for the

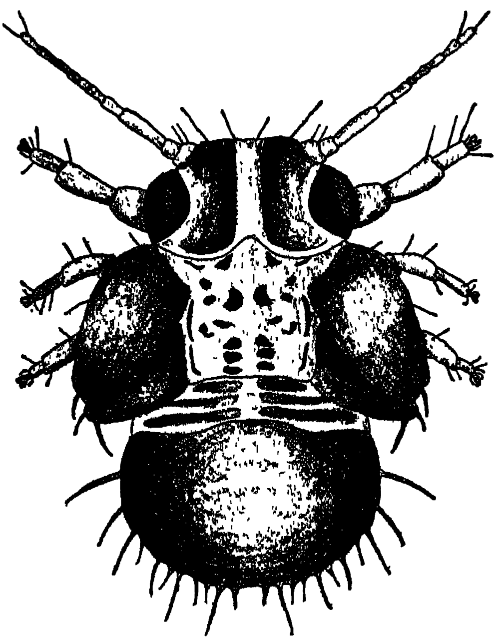


FIG. 9. A YOUNG PSYLLA (much enlarged)

next year, thus cutting short the succeeding crop. If nothing is done to check the pest, the trees will become weakened and unable to withstand the attacks of future hordes of the psyllas, the blight, rust and other enemies that always come to exhausted plants. Moreover, each psylla secretes minute drops of a clear sweet liquid known as honey-dew, which finally spreads over the leaves, branches and fruit in a sweet sticky coating. The honey-dew offers a favorite medium for the growth of a black, sooty fungus that soon coats the leaves, branches and fruit wherever the sweet material has lodged. This fungus does no particular harm to the tree except to give it a forbidding appearance while the fruit is so blackened that it has sometimes to be washed before being presentable for the market.

The full-grown psyllas pass the winter in crevices of the bark or in the crotches of branches beneath accumulated leaves, and with the first warm days of spring become active and begin to lay their tiny orange-yellow eggs about the buds and along crevices in the bark of the smaller branches. The eggs hatch in two or three weeks, depending upon the temperature, and the young psyllas begin at once to suck juices from the tender leaves. The young psyllas are wingless but active and grow rapidly so that they become full-grown in two or three weeks (Fig. 9). Thus the whole life cycle, in the height of the season, may be passed through in one month. There is time for four broods, at least, so that toward the end of the season the psyllas are often present in enormous numbers and cause very great injury.

This pest of pears has proved to be a very difficult one to control. One must not expect to check it successfully without thorough and persistent effort. Perhaps the most effective material for the destruction of the young and adult psyllas is a commercial product of tobacco known as "nicotine sulphate". The advantage of this commercial product is that it contains a known amount of nicotine, 40 per cent in the better known brands, and can be used intelligently. Tobacco extracts can be made by steeping stems in water, but since tobacco varies greatly in the amount of nicotine it contains one never knows what strength of solution is obtained.

The adult, over-wintering psyllas may be killed by spraying the trees thoroughly in the late fall or early spring while the tree is dormant with nicotine sulphate (40 per cent) at the rate of $\frac{3}{4}$ of a pint to 100 gallons of water. To this amount of mixture there should be added 4 or 5 pounds of soap which will cause the tobacco solution to stick and to spread better than it otherwise would.

The adults are very active, and it is probable that not all of them will be hit by the liquid, in which case those that escape will remain to deposit eggs later. As soon as the eggs hatch and the young psyllas appear they may be very effectually destroyed by spraying the trees with the same solution. In heavily infested orchards two or three successive applications, a few days apart, may be necessary. The addition of 25 pounds of hydrated or quicklime to each 100 gallons of the mixture has proved of value.

Plums are often scarred on the outside and often contain "worms" inside next to the pit. In the majority of cases the scars are due to the work of the plum curculio and the white, half-curled "worm" inside is the larva or grub of this insect. The plum curculio is undoubtedly the most important insect pest of the plum, although it by no means confines itself to this fruit. It attacks the apple, peach, cherry, apricot and pear in about the order of importance named. The plum curculio is a native insect and is widely distributed throughout the middle and eastern United States. One authority estimates that it causes a yearly loss of over $8,500,000, and although it has been known as a fruit pest for over a century no wholly satisfactory method of control has yet been found.

The full-grown curculio is a small, mottled, black and grayish beetle about $\frac{1}{5}$ of an inch in length, with two prominent humps near the middle of the back and a long, slender, trunk-like snout or proboscis with a pair of sharp and efficient jaws at the end. The small beetles pass the winter hidden beneath leaves and rubbish along old hedgerows, and in the borders of woodlands. In the spring they appear and begin to attack plums, apples, peaches and other fruits. The curculio makes two kinds of scars on the outside of the plums. One known as the feeding scar is a circular, shallow pit caused by the beetles feeding on the fruit. The other made by the female in depositing her egg is very characteristic because it is crescent-shaped and usually very clearly so (Fig. 10). The female curculio makes a hole in the pulp of the fruit with her snout, then deposits a white egg in it and then with her snout cuts a crescent-shaped scar just in front of the hole (Fig. 10). The egg hatches in a few days and the whitish grub burrows through the flesh. In about 20 days it becomes full-grown and then enters the soil under the tree to the depth of an inch or two, where it makes a tiny chamber and changes to a pupa. In about four weeks from the time the grub goes into the ground the full-grown beetles come forth and feed for a time on the fruit remaining on the tree and then hide away in their winter retreats, thus completing the life cycle, there being but one generation each year.

Cleanly cultivated, carefully pruned and well-cared for orchards are less subject to the attacks of the curculio, and this is true of many insect pests. Old hedgerows, stone walls and fences grown up to vines, bushes and weeds surrounding the orchards should be cleared away, because it is in such places that the curculios find favorable places for passing the winter. Frequent and thorough cultivation of orchards during July will break up the cells of the pupæ and bring about their destruction. The trees should be judiciously pruned, for direct sunlight on the infested fruit lying on the ground will kill the grubs. Finally, the trees should be sprayed soon after the petals fall and again ten days later with arsenate of lead, 5 pounds in 100 gallons of water, or of Bordeaux mixture, the latter often being used to control the brown rot, a common disease of plums.

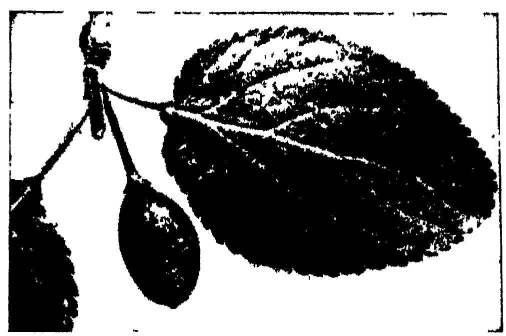


FIG. 10. A PLUM SCARRED BY A CURCULIO

In some localities in our country it is next to impossible to grow cherries that are free from "worms". Some of these "wormy" cherries are caused by the grubs of the plum curculio, but many of them, especially in the northern United States, are due to the cherry maggots, which are the small, white larvæ of certain flies that deposit their eggs just beneath the skin of the fruit There are two species of these cherry fruit-flies, but they are so nearly alike in size and appearance that only an expert can tell them apart. Each one is a little smaller than an average house-fly, and each of them has dark stripes or bars running crosswise of the wings. They appear

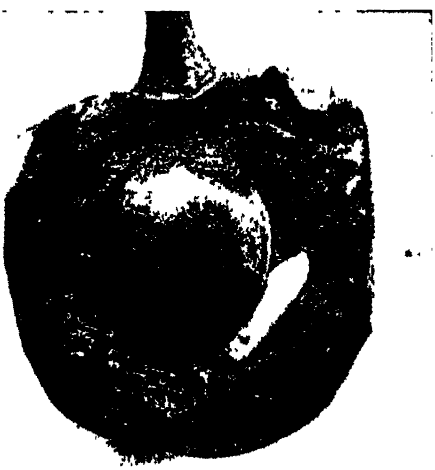


FIG. 11. A CHERRY INFESTED WITH THE MAGGOT OF A CHERRY FRUIT-FLY

about the time the cherries begin to redden and soon begin to thrust their tiny white eggs into the cherries. Here the eggs hatch and the small white maggots begin to burrow through the flesh of the cherry, especially around the pit (Fig. 11). In three or four weeks the infested cherry becomes sunken on one side and decay sets in, although the fruit does not fall from the tree. Even at picking time many of the "wormy" cherries show no indication from the outside of the presence of the maggot within.

When the maggots become full-grown they leave the cherries and go into the ground to the depth of about one inch and change to hard brown puparia, which remain in the soil until the following spring or nearly ten months. There is, therefore, but one generation a year.

These flies attack both sweet and sour cherries, the Morellos and Montmorencies usually suffering the worst.

Careful observations have shown that the flies are in the habit of sucking up drops of moisture that they find on the leaves of the tree. Advantage has been taken of this habit by spraying the trees with a small amount of sweetened, poisoned water. Most satisfactory results have been obtained by using arsenate of lead at the rate of 5 pounds to 100 gallons of water and adding 3 gallons of cheap molasses to sweeten it. Each tree should be rather thoroughly sprayed with this mixture, although a heavy coating is not necessary. The sweetened bait is easily washed off by rain and should be renewed after a storm.

The peach is subject to the attacks of a number of rather serious insect enemies, but perhaps the peach-tree borer is the most common and most important of all. It is found in the United States and Canada east of the Rocky Mountains wherever the peach is grown, while along the Pacific Coast a closely related species with very similar habits exists and constitutes a troublesome pest. It is estimated that the peach-tree borer causes an annual loss in this country of at least $6,000,000. Trees of all ages are attacked and young trees are often killed outright, while older trees are greatly weakened in vitality and resistance to the attacks of other pests.

The borer is the caterpillar of a beautiful steel-blue moth (Fig. 12). When full-grown it is yellowish white in color and about one inch long. It spends its life just under the bark of the larger roots and also of the trunk, usually below the surface of the soil, where it makes furrows partly in the bark and partly in the sapwood, sometimes completely girdling a tree (Fig. 13). The presence of the borers causes the exudation of large masses of gum which may be found on the ground around the bases of infested trees. These accumulations of gum are a pretty sure indication of infestation by this insect.

The borers pass the winter in their burrows, complete their growth in the spring and change to pupæ in rough brown cocoons made partly of silk and partly of particles of bark and other débris.

FIG. 12. ADULT MOTHS OF THE PEACH-TREE BORER

The cocoons may be found at or near the surface of the ground at the base of the tree in July and August. In three or four weeks the pupæ change to the parent moths.

The male and female moths are considerably different in their appearance. Both have steel-blue bodies, but the abdomen of the female differs from that of the male in having a broad orange-yellow band around the middle. In addition all four wings of the male are transparent, while only the hind wings of the female are clear, the front pair being thickly covered with blue scales (Fig. 12). The female moth deposits many tiny eggs on the trunks of peach trees in July and August. Here they hatch into the tiny borers which enter the bark and cause the injury as explained. Thus there is but one generation each year.

Many washes and many devices have been tried to prevent the attacks of this insect, but without much success until recently. In fact, the most common way of controlling it has been to dig the borers out at least once a year. In digging out the borers the earth is hoed away from around the base of the tree to a depth of three or four inches. The masses of gum will indicate where the larvæ are at work and with a sharp knife the bark can be cut away and the borers exposed in their burrows and killed. In badly infested orchards the borers may be dug out in the fall and in the spring during the first part of June.

Recently a white crystalline substance known by the long chemical name of para-di-chloro-benzene has been used with fine success. In applying the material the crust of earth is scraped away around the base of the tree. Then $\frac{3}{4}$ of an ounce to 1 ounce of the crystals is scattered in a band about two inches wide all the way around the trunk (Fig. 14) and promptly covered with two or three shovelfuls of soil packed down with a few strokes from the back of the shovel. The para-di-chloro-benzene should be applied in the northern states about September first, while in Georgia about October first would be the proper time. It should not be used, however, on trees that are less than six years old.

FIG. 13. TRUNK OF A PEACH TREE INFESTED WITH THE PEACH-TREE BORER

During the last two decades the grape industry in the eastern part of this country has suffered greatly from a comparatively new pest, the grape root-worm. The rose-chafer and the grape-vine flea-beetle have also, during this period as well as previous to it, contributed to the losses to which grape growers have been subject from year to year. But perhaps the most common and widespread insect enemy of the grape is the grape leafhopper. It is present and more or less injurious in nearly every vineyard in the United States and Canada and, in some seasons, is very destructive. In California it is, next to the phylloxera, the worst insect pest of the vine.

FIG. 14. PEACH TREE TREATED WITH A RING (¾ OUNCE) OF PARA-DI-CHLORO-BENZENE

Both the young and the full-grown hoppers live on the leaves of the grape and with their tiny beaks suck up the sap and deprive the vine of its requisite nourishment. As a result of this, the leaves turn brown and fall from the vine, the fruit does not mature and ripen properly, and the vine itself is prevented from developing new wood for the production of grapes during the succeeding season.

The leafhoppers when full-grown are light in color but mottled with darker spots, and are scarcely an eighth of an inch in length. When abundant they fly up in swarms if the vines are disturbed. They pass the winter hidden away in the grass and leaves along ditch banks or the borders of woodlands. In the spring they come forth from their hiding places and begin feeding upon almost any green plants they can find. Later, as soon as the foliage appears, they go to the grapes, where they live almost entirely on the under sides of the leaves. In two or three weeks they begin to thrust their tiny eggs into the tissues of the leaves just beneath the lower skin. The eggs hatch in ten days to two weeks, but it takes about one month for the young hoppers to become full-grown.

In California and such localities where the season is long there are two full broods each year and the hoppers become exceedingly abundant in July and August. The foliage turns brown and the leaves fall, while the fruit fails to ripen and does not acquire its proper color, flavor or sweetness.

In the case of the leafhopper we have a pest for which clean culture is decidedly beneficial. Hedgerows, grassy ditch banks and borders of near-by woodlands should be cleaned up to destroy the winter hiding places of the insects. In addition, clean cultivation of vineyards to destroy the weeds and plants upon which the hoppers live in the spring before the foliage of the grape appears, is of very material aid in holding this grape pest in check.

In California some vineyardists make a practice of catching the hoppers in mosquito-screen cages. The cage is smeared on the inside with kerosene or crude oil and is set over an infested vine. By jarring the vine the hoppers are disturbed and are caught in large numbers when they strike the oil.

In eastern vineyards the hoppers are controlled by spraying the vines with nicotine sulphate (40 per cent) at the rate of 1 part to 1000 parts of water. Thorough work is necessary, for the young hoppers must be hit with the liquid in order to be killed, and the spray must therefore be directed upwards and on to the under sides of the leaves, if one is to expect any real success with its use.

Raspberries are fairly free from insect-enemies, but in June one will often find the tender tips of the new shoots (Fig. 15) wilted and fallen over. One can be almost sure that this type of injury is due to the work of the raspberry cane-borer. The adult insect is a slender, handsome beetle about half an inch in length. The body is black except the neck just behind the head, and this is reddish yellow and bears two or three black spots on the upper side.

The beetles appear in June and deposit their slender, white eggs in the pith of the tender shoots of the raspberry. Before depositing her egg she girdles the cane twice about half an inch apart and then inserts the egg into the cane between these two girdles. As a result of the girdling the tip of the cane wilts and drops over to one side. The egg hatches and the grub bores down the cane toward the root, but does not get far the first summer The next season, however, it reaches the base of the cane and kills it entire. The following spring the grub goes through its transformations and the parent beetle appears, thus completing the life cycle.

FIG. 15 RASPBERRY SHOOTS INJURED BY THE RASPBERRY CANE-BORER

This pest is best controlled by cutting off the wilted shoots two or three inches below the girdles. The custom of cutting out and burning the old dead canes every fall is a good one, for, in this way, many of the grubs are destroyed before they have changed to beetles.

Photo Southern Field Crop Insect Investigations, U. S Dept of Agriculture

"DUSTING" A FIELD OF COTTON FOR THE MEXICAN BOLL-WEEVIL

HABITAT GROUPS OF NATIVE WILD GAME BIRDS

PRAIRIE CHICKEN

Photos American Museum of Natural History, N. Y.

WILD TURKEY

OUR COMMON BIRDS VII

The Wary Grouse, Vanishing Turkeys,
Friendly Quail and Gorgeous Pheasants

THE UPLAND GAME BIRDS

THERE are many ways in which birds serve man, but none has been recognized for so long a time as those of food and sport. Ever since man began throwing stones, the flesh of birds has formed an important item in his diet. With the coming of agriculture and the domestication of animals, birds assumed an even more important part in the economy of the table, and today millions of dollars are spent each year in raising domesticated birds so that man can vary his diet of beef and pork and mutton. The strangest part of it is that so few birds have entered into the economy of man. All our domestic ducks, with the exception of the muscovy, have come from the mallard; all our pigeons from the rock dove; all our turkeys from the Mexican turkey; and all our various breeds of chickens from the red jungle fowl of India. Other closely related species have given us nothing. It is one of the ways of nature to select one species for glorification.

Mother Nature is a great specializer. Every organism develops and becomes specialized or adapted for some particular function. Some are constructionists and others are destructionists, and always the two are balanced. The plants are the builders and the animals are the destroyers. And lest some of the destroyers become too numerous, other animals are the destroyers of these.

In the course of ages, this is the only way in which life can continue to exist. Otherwise there could be no progress, and each organism by its own growth and multiplication would starve itself and all others into non-existence.

In this scheme of nature, there is one group of birds which seems to be designed to be the legitimate prey of the larger carnivorous birds and animals, including man. This is the group of game birds. Their habits are such as to develop the greatest bulk of meat for their size, and their food is such as to give to it a tenderness and flavor highly desired. Their food habits are not such as to make them needed in fighting the insects, their colors are usually dull, and they have no songs. Indeed, their greatest charm is in their wildness and the subconscious knowledge that they are prized as food. Some of these game birds frequent the lakes and marshes, others the upland woods and fields. The latter include all of the fowl-like or gallinaceous birds which are treated in this chapter.

Some authorities place all of these gallinaceous birds, the turkeys, grouse, partridges, quail, guinea fowls, pheasants and peafowls, in one family, *Phasianidæ*, but here in America we are accustomed to put each group in a family by itself. Thus we have the *Tetraonidæ* or grouse, the *Odentophoridæ* or partridges and bob-whites, the *Meleagridæ* or turkeys, etc. There is likewise considerable confusion in the usage of the common names "grouse", "partridge" and "quail". These names are applied to quite different birds in different parts of the country and interchangeably in others. It would be difficult to convince most hunters in the northern United States that the ruffed grouse was nót a partridge, and that the bob-white is not a quail, but strictly speaking, the true quails are all Old World members of the

family *Perdicidæ*, and the New World bob-whites, California quail, etc., belonging to the family *Odontophoridæ*, should be called partridges or perhaps New World quail. This takes the name "partridge" away from all the grouse which belong to the family *Tetraonidæ*. Finally, the name "pheasant" is just as inappropriate for the members of the grouse family as "turkey" would be for the pheasants, and yet in some parts of the country the ruffed grouse is called the pheasant. In general, grouse can be distinguished by having the tarsus or lower leg more or less covered with feathers, in some species extending to the tips of the toes. The partridges or New World quail have the tarsus bare and without spurs, while the pheasants have it bare but with well-developed spurs.

The wary grouse

There are about 25 species in the grouse family, confined to the northern parts of the northern hemisphere, two species of ptarmigan being circum-polar and found both in Europe and America. The majority of species, however, are more or less restricted in their range, and the individuals are often sedentary and spend their entire lives within the confines of a small woodland. During the nesting season they are solitary, but afterwards the young stay with the parents, and sometimes different families come together about good feeding spots, and good-sized covies are formed.

Photo A. A Allen

A HAND-REARED RUFFED GROUSE THAT LIKED TO PLAY

Grouse are ordinarily terrestrial, although when alarmed they often fly up into the trees, and during the winter they secure a good deal of their food from the buds. They are not shy unless hunted continuously but allow a close approach, relying upon their protective coloration. When they do fly, it is with a startling whir of the wings that is quite disconcerting to the average hunter. Their flight is rapid and direct, although they usually follow the arc of a circle and do not fly far. Indeed, when flushed several times, and driven to the edge of its circumscribed area, a grouse will often double back right over the head of the pursuer.

Grouse ordinarily nest on the ground, the woodland species at the foot of a tree or beneath a fallen branch, and lay from eight to fifteen eggs. The young are covered with down when hatched and are able to run about. Their wing feathers are the first to grow, and they are able to fly when about a week old although they are still very small. The male bird does not ordinarily help in their care. Indeed, he is usually never seen near the nest or brood until they are full-grown. The female, however, is very solicitous for the safety of the young and uses every expedient to distract the pursuer, trailing her wings along the ground as though severely wounded, to attract attention to herself rather than to the young, and hissing like a snake or even flying into the face of the pursuer The young crouch at the danger call and do not move until once more called by the mother. As they are always scattered it makes it a very difficult task to find them, so protectively colored are they.

The best known of the grouse family are the ruffed grouse, the spruce grouse and the heath hen of the East, and the dusky or blue grouse, the Franklyn's grouse, the prairie chicken, the sharp-tailed grouse and the sage grouse of the West. The northern ptarmigan are represented in

Photos by A A Allen

RUFFED GROUSE STRUTTING
(Bird raised in captivity.)

RUFFED GROUSE IN WINTER
Puffed out to keep warm (captive bird).

Colorado by what are locally known as "white quail", a southern form of the white-tailed ptarmigan.

The most generally known, and the game bird par excellence, is the ruffed grouse which in one or another of its forms is found in wooded districts from Virginia to Alaska. It gets its name from the tufts of large black or brown feathers on the sides of the neck which can be lifted and spread until the head is framed as in an Elizabethan ruff. The broad, banded tail is always spread when the bird flies and is one of the simplest ways of distinguishing it from a female pheasant or any other of the game birds. Before they learn the fear of man and the gun, ruffed grouse or "partridges", as they are generally called, are tame birds and merely walk out of one's way along the forest trails, but it takes but very little hunting before they become shy and it taxes the utmost skill of the hunter to approach them even with the aid of a dog trained to "point".

The most interesting characteristic of the ruffed grouse is its habit of drumming. The cock bird selects some fallen log to which he returns often for years. Drumming is at its height during the spring but even after the breeding season, on bright days during the fall and winter, the old cock may come back to his favorite log.

Photos by A. A Allen

NEST AND EGGS OF RUFFED GROUSE

YOUNG RUFFED GROUSE HATCHING

The nest is at the foot of a stump.

The drumming sound, which begins with a measured thump—thump—thump and ends with a loud whirring sound like the muffled sound of a motorcycle engine, is made by the cock beating the air with his wings. Between his drumming performances and while waiting for the female to approach, he struts up and down the log much like a miniature turkey gobbler with tail spread, wings drooped and ruff erected.

The spruce partridge of the Northeast and the Franklyn's grouse of the West are both inhabitants of the moist spruce forests, where their dark coloration seems quite in keeping with their surroundings. The males are easily distinguished from the ruffed grouse by the absence of ruffs and by the largely black underparts The females are much browner but have black tails with but one band of brown at the tip. Both species are known as "fool hens" because of their misplaced confidence in man. They seem to have absolutely no fear and will barely get out of one's way in the forest and will often allow themselves to be killed with a stick. For this reason they cannot compare with the ruffed grouse as game birds.

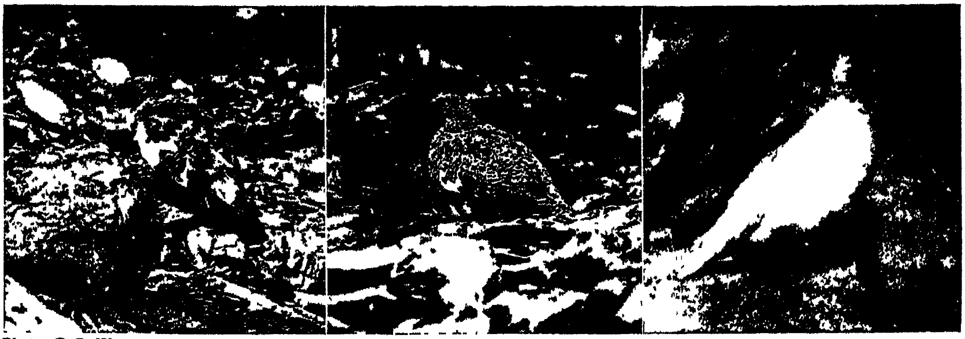
THE NEARLY EXTINCT HEATH HEN OF MARTHA'S VINEYARD

The dusky or blue grouse is found in one or another of its three forms from the mountains of Arizona to Alaska. It is considerably larger than the other grouse, of a nearly uniform bluish slate color mottled with brown on the wings. Where not hunted it is as unsuspicious as the spruce grouse, but like the ruffed grouse it soon learns to evade the hunter and makes a splendid game bird.

The prairie chickens, sharp-tailed grouse and sage grouse are birds of the open prairie or sage-brush country of the West. With the advance of agriculture into their domain, they have been pushed further and further westward and have been exterminated over a good part of their former range. The different birds, while resembling each other superficially, are quite easily distinguished: the prairie chicken by its pencils of elongated feathers on the sides of the neck and its square tail, the sharp-tailed grouse by its similar appearance but pointed tail, and the sage grouse by its large size, pointed tail and black on the underparts. All three species have interesting courtship performances in the spring which are quite different from those of the ruffed grouse. The prairie chickens, for example, assemble in small companies on knolls or open places on the prairie where the males compete for the females. Large inflatable sacs are distended on the sides of the neck to the size and color of small oranges, the stiff feathers are erected, and a loud booming sound is produced by expelling the air from the sacs. They then dance about and fight and rush at the females of their choice to win their attention.

The eastern form of the prairie chicken, called the "heath hen", formerly found throughout the coastal plain of southern New England and the Middle States, is now extinct except for a small flock rigidly protected on Martha's Vineyard.

The ptarmigan are unusual birds which become pure white in winter, their summer plumage being mottled gray and brown like the lichen-covered rocks. They are birds of the Barren Grounds, or the mountain tops above timber line, and are always associated with snow and glaciers. The only exception to this is the red grouse of Great Britain, which lives on the moors



Photos E R Warren

MALE WHITE-TAILED PTARMIGAN (Summer plumage) FEMALE WHITE-TAILED PTARMIGAN (Summer plumage) WHITE-TAILED PTARMIGAN (Winter plumage)

It has the distinction of being the only ptarmigan which does not turn white in winter and is the only species of bird that is confined to the British Islands. The other European grouse are the black cock, the large capercaillie and the hazel hens.

The vanishing turkeys

Why our Thanksgiving bird bears the name of "turkey" will always be a mystery So long ago was it christened that we can never expect to learn whether the *nom de plume* originated in some mistaken notion of the bird's native land or whether it was given it in an effort to translate its call of "turk — turk — turk." At any rate, turkey it is and always will be to the small boy with a drumstick in each hand or to the scientist who writes after it *Meleagris gallipave*.

There are two species of wild turkeys, but the second, called the "ocellated turkey", will doubtless never become of importance outside of museums because it is restricted to the peninsula of Yucatan and a small portion of the adjacent parts of Guatemala and Honduras and shows no propensities for domestication or artificial extension of its range Nevertheless it is a beautiful bird, smaller than the common wild turkey, with purplish reflections on its back and with eyelike spots on its tail in addition to the typical bands The body feathers are tipped with brilliant golden and coppery bronze and the head and wattles are deep blue covered with orange tubercles. In brilliancy, it is suggestive of some of the pheasants, and it even vies with the peacock in splendor.

The common wild turkey, which was originally found from Maine and southern Ontario to southern Mexico, varies to such an extent in different parts of its range that five recognizable forms or subspecies have been recognized: one from southern Mexico, one from northwestern Mexico and Colorado, one from northeastern Mexico and Texas, one from southern Florida, and the common wild turkey, found from Georgia to Maine and Ontario. It is from the south Mexican that our domesticated bird is descended, the tail coverts and bands in the tail of each being gray while corresponding parts of the common wild turkey are a rich chestnut. It is supposed that birds domesticated by the Indians were brought back to Europe by the conquistadors because they had become established in many parts of Europe as early as 1530. Domesticated birds were brought to North America by the colonists, and many it is believed, hybridized with the wild turkeys, as they still do where opportunity offers, until in some places where the wild turkey is still found it is rather difficult to find pure wild blood.

The wild turkey was originally an inhabitant of the open woodlands of all the Eastern States and those as far west as Kansas and Oklahoma. Today it has been exterminated in New York and New England and is confined to the rougher and more remote portions of Pennsylvania and Virginia, the larger swamps of the Southern States and thinly settled portions of the Mississippi Valley and is everywhere fast following the passenger pigeon and Carolina parroquet into history.

It is possible, however, to breed the wild turkey in captivity. and several farms for the purpose have been established The state of Pennsylvania, at least, is trying to restock its wilder game coverts with these magnificent birds and has released many obtained from the game farms.

In its habits, the wild turkey is not very different from the domestic bird. Except during the breeding season, they live in small flocks of from six to twelve individuals of both sexes, feeding upon acorns, nuts, etc., and ordinarily roosting in the same trees each night. At the beginning of the breeding season in March, the flocks disband and the males begin to gobble. Gobbling corresponds to the drumming of the grouse or the crowing of the rooster and usually is heard only early in the morning before the bird leaves the roost. When he has been successful in attracting a female, he struts and displays like the domestic bird. Turkeys are polygamous, and frequently rival males engage in fierce battles, the victor becoming lord of several females. After incubation begins, the males lose their animosity toward each other and again flock together, leaving the cares of the family entirely to the females.

The wild turkey is our largest and finest game bird. With the increase of agriculture and the disappearance of our forests it is to be expected that its range will be greatly restricted, but as long as we have national and state forest preserves and rough country that the plow cannot turn, we should have wild turkeys Greater effort should be made by the national government and the various state conservation commissions to save the remnant of these splendid birds and to reintroduce them.

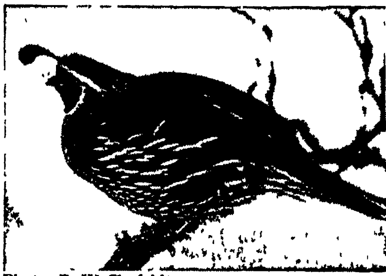
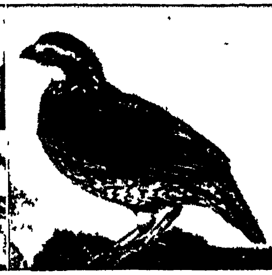
The friendly quail

At the other extreme in size from the turkeys among the upland game birds are the quails (family *Odontophoridæ*). Some of the Old World species are no larger than sparrows, and our American quails are smaller than pigeons. The American quails, of which there are about 100 species, differ from the true quails and partridges of Europe in having the cutting edge of the bill slightly serrate or finely toothed instead of smooth, and also in the entire absence of spurs on the legs. The majority of these are confined to the tropics but seven species are known north of the Mexican boundary. Of these, the bob-white is best known in the East and the California quail on the Pacific Coast.

The bob-white is native as far west as Colorado but has been introduced into New Mexico, Utah, Idaho, California, Oregon and Washington. It has always been a favorite game bird and throughout the South has been fairly well able to hold its own. Of recent years, however, because of its destruction of cotton-boll weevils and other agricultural pests, a sentiment has been growing up in favor of removing it from the game list, and some states are now giving it complete protection. Its cheery call of "bob-white" is the most musical of any of the notes of the game birds, which, together with its confiding habits, is almost enough to put it on the song bird list. When hunted, however, it becomes almost as wary as the grouse, and in the many states where there are no grouse and pheasants do not seem to do well, there is nothing to take its place as a game bird.

Except during the breeding season, bob-whites are found in covies which are usually members of one family though sometimes where food is abundant the different covies join, forming large flocks. They feed about open fields, hedgerows and even gardens, and when alarmed they usually run together before taking wing and then get up with a rumble that is quite confusing. At night they form a close circle, their little tails together and their heads pointing out, a veritable bomb ready to explode at the approach of an enemy.

The bob-white is not polygamous, as are the grouse and turkeys, and the male bird is a conscientious father and helps incubate the eggs and care for the young. The nest is a mere depression in the ground beneath a fallen branch or where the dried grass is thick enough to help form the arch or roof which usually conceals the eggs from above. The ten to eighteen eggs are the whitest and most pointed of any of the gallinaceous birds.


Photos R W Shufeldt

CALIFORNIA QUAIL — TEXAS BOB-WHITE — CHESTNUT-BELLIED SCALED QUAIL

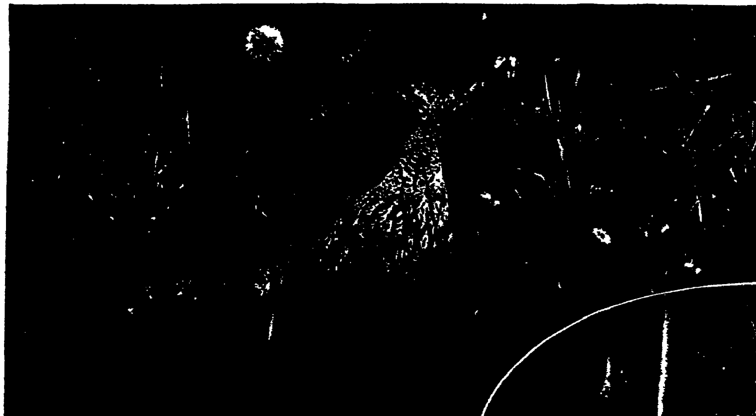
The "bob-white" call is seldom heard after the eggs are hatched, for in its place another is given that helps keep the family together. They remain together, unless scattered by hunters, until the following spring, never migrating but often moving in from the fields to the wooded bottom lands and alder thickets for the winter. The winters in New York and New England are often too severe for them, for the deep snows cover all the woods and fruit-bearing shrubs and the bob-whites have not learned to mount into the trees and live upon buds as do the grouse. The male can be distinguished from the female by the white throat and band over its eyes, the markings of the female being buff. The bob-whites of Florida are considerably smaller and those of Texas are grayer, and they have been separated into different races. In southwestern Arizona and adjacent Mexico lives the curious "masked bobwhite" with a throat that is black instead of white and with chestnut underparts.

In the Rocky Mountain region and the Pacific States, the bob-white is replaced by the California quail. It is a very different appearing bird, being bluish-gray rather than brown and having its head adorned by a few black recurved feathers that are bare at the base and swollen at the tip so as to resemble a jade ornament rather than a crest. In the interior of California and Oregon the birds are paler and grayer and have been separated into a different race and called the "valley quail". In the arid parts of the West, from Texas to Southern California, there is a quail very similar to the California quail but with chestnut flanks. It is called the "Gambell's quail". The plumed or mountain quail is a larger bird with a crest of few straight feathers. It is a shier bird, seldom coming near habitations, and preferring the open forest or chaparral growth on the mountains. As with the California quail, the birds inhabiting the humid coast region are much darker and those on the arid ridges grayer. The former is called "mountain", and the latter the "plumed partridge".

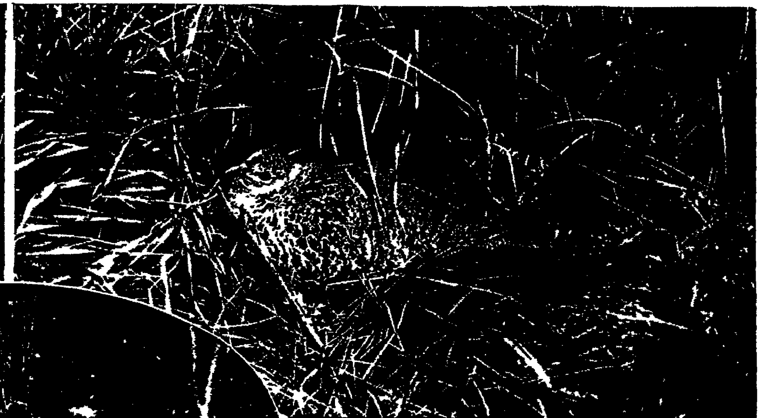
Two other quail are found in the West, the scaled partridge and the Mearn's quail. They are found in the desert country from western Texas to Arizona but the former is much the more abundant. The scaled partridge, blue quail or "cotton top" as it is variously called, is gray in color, the feathers of the neck and breast edged with black, giving it a curious scaled appearance. Partially concealed on the crown is a tuft of white feathers that give it the last name. The Mearn's quail is smaller than the bob-white and has its black underparts spangled with white spots and its head striped with black and white.

All of these quail, with the possible exception of the Gambell's, have been giving way before the advance of agriculture and the ever increasing number of hunters. In spite of their great reproductive capacity, the laws regulating the open seasons and the number that can be killed will have to be stiffened to make up for the increasing number of hunters and their decreasing range. One encouraging feature is the fact that they are now being bred in captivity and each year sees the methods employed on the game farms reaching greater perfection and larger and larger numbers being raised. It is with the pheasants, however, that game farming has reached its greatest perfection and has succeeded in adding a valuable bird to the faunas of many states of the Union.

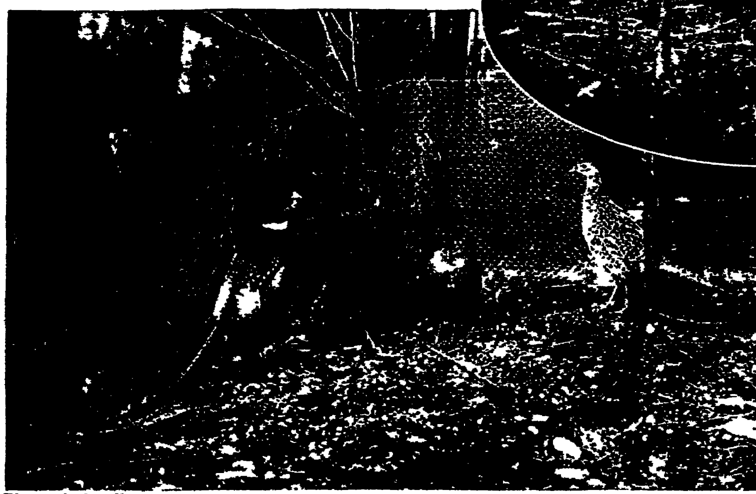
RING-NECKED PHEASANTS IN THE WILDS AND ON THE GAME FARM



LEADING HER CHICKS THROUGH TALL GRASS



FEMALE INCUBATING ON HER NEST



Photos A. A Allen

BREEDING PEN OF RING-NECKED PHEASANTS ON A GAME FARM

YOUNG RING-NECKED PHEASANTS WITH THEIR FOSTER MOTHER

WILD RING-NECKED PHEASANT

The gorgeous pheasants

There are about 100 species of true pheasants (family *Phasianidæ*) found through central and southern Asia to the Malayan region. The majority are brilliantly colored birds, though the females are dull, and many species are seen in the aviaries in this country. The resplendent golden and Lady Amherst pheasants, from western and southern China, with their wonderful capes and arched tails, are perhaps the most brilliant of all. The golden pheasant has been released in western Oregon and on Protection Island with some success, and the silver, the copper and the green pheasants also, but the only one really successfully naturalized is the ring-necked, now a member of the faunas of at least 25 states.

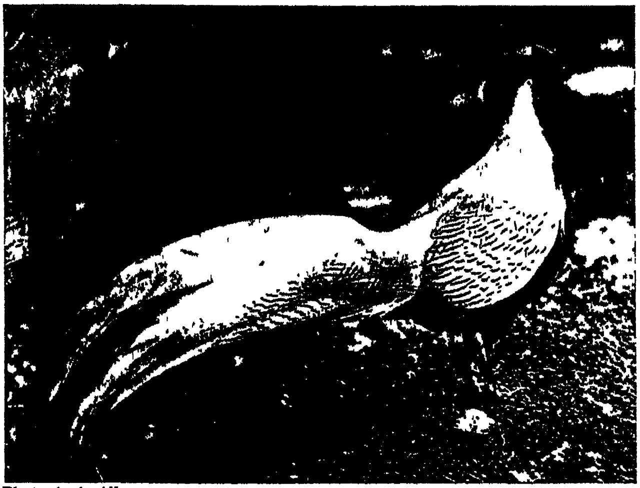
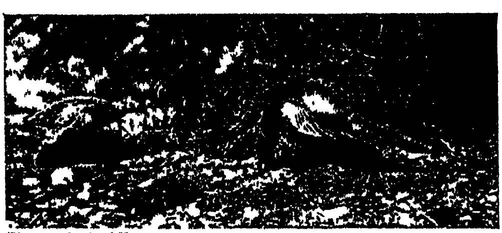


Photo A A Allen

MALE SILVER PHEASANT

The ring-necked pheasant is not a real species but is a hybrid between the English pheasant (*Phasianus colchicus*) and the Chinese ring-neck (*P. torquatus*) and was brought over from England, where it originated. The male is a very ornamental bird with a bright metallic green head and a more or less continuous white ring around the neck Its breast is a rich coppery chestnut, its back marked with gold and chestnut, the rump being greenish gray and the long tail banded with rich brown and buff. The female is uniformly brown spotted with darker, on the back, and were it not for her long pointed tail might be confused with the ruffed grouse.

Naturalizing a foreign bird or animal in any land is a risky undertaking as evidenced by the English sparrow and the starling in this country, which have increased far beyond control and, instead of functioning, as intended, in the destruction of insects, are rapidly replacing more valuable native birds. The naturalization of the pheasant seems to present no such difficulties, for although, when too abundant it is likely to become destructive to crops, it will always be such a valuable addition to the food supply that the slightest relaxation in the laws regulating its capture would result in its extermination. Nor is there any danger of the pheasant replacing any of our native game birds. It is a bird of the open fields and hedgerows and might in a measure compete with the bob-white except that it does not do so well in the South where the bob-white does best. In the Northern States it does not compete with the ruffed grouse because they live in different habitats, so that, all in all, it is surely a valuable addition to our upland game birds.

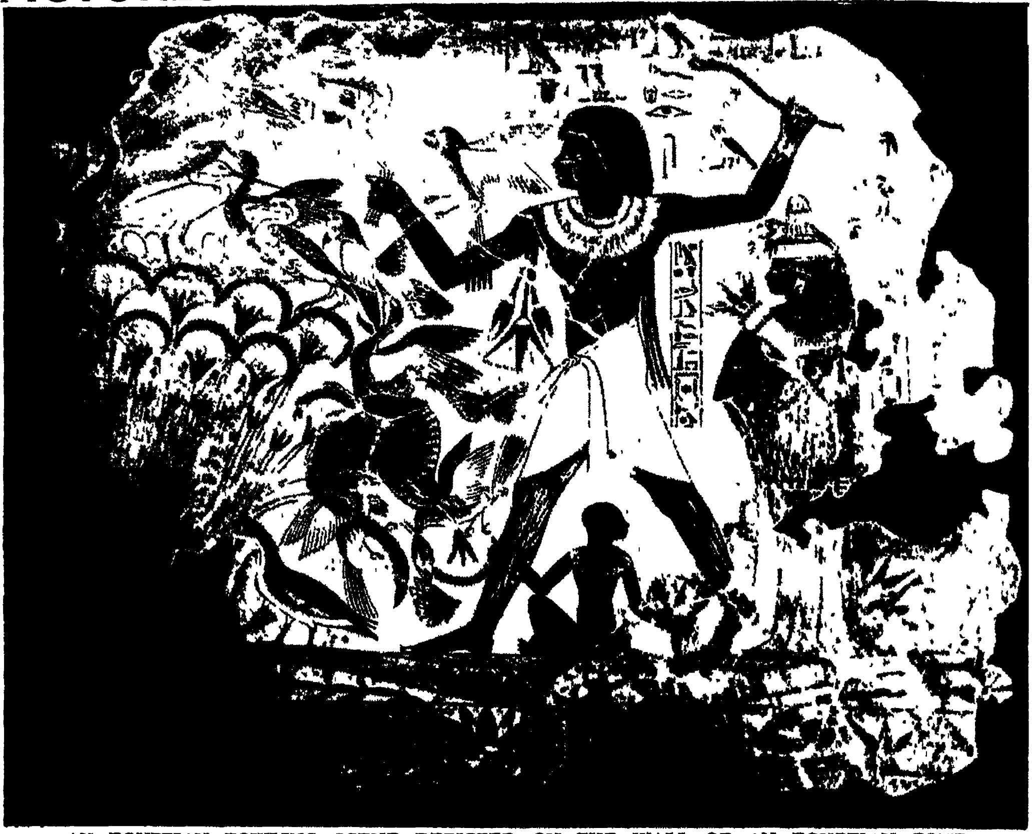


Photos A A Allen

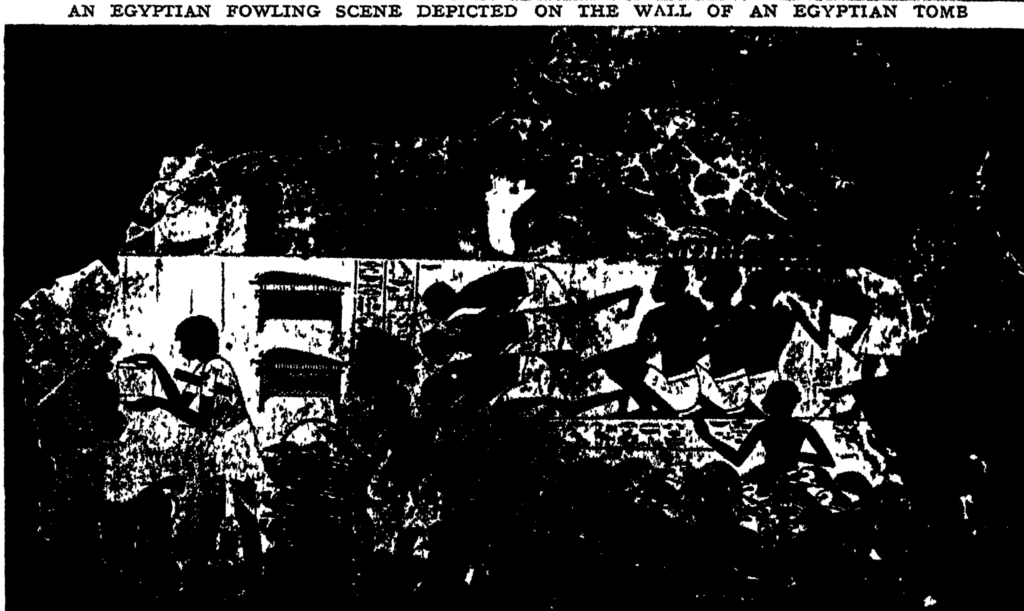
RING-NECKED PHEASANT DISPLAYING TO FEMALE

GOLDEN PHEASANT DISPLAYING TO FEMALE

PICTURES FROM WHICH WRITING GREW



AN EGYPTIAN FOWLING SCENE DEPICTED ON THE WALL OF AN EGYPTIAN TOMB



MURAL PAINTING OF THE INSPECTION AND COUNTING OF A FLOCK OF GEESE IN ANCIENT EGYPT

Pictures, or hieroglyphics, were first drawn to tell a story; then the figures were condensed into symbols, and the symbols shortened into letters that formed an alphabet; and so writing began.

INTELLIGENCE AND SPEECH

How Intelligence Has Grown with the Growth of Speech, and Thought Forms Itself in Speech

THE SPEECH-CENTER OF THE BRAIN

THE study of the senses, of association, memory and attention, leads us on to intelligence, which is ultimately associated with words and speech. The intelligent man does not necessarily write or speak at any given moment, but at least he thinks, and he cannot think above the lowest level without words. Thus the process of thinking, the intelligent process, is intimately bound up with speech.

Long ago we saw that the nervous system is a sensory motor arrangement, which feels and replies. The brain itself is none other, fundamentally, than a sensory-motor mechanism; and if we study it as the organ of intelligence, we see its sensory side, above all, in terms of the hearing of speech or the seeing of written language; and its motor side in the act of speech, or in the act of writing. Nowadays, all of us who can read and write have this double mechanism, but in an earlier stage we simply have the original mechanism of hearing the sounds we call words, and reproducing them. The duplication of this primary process by means of writing and reading has had immeasurable consequences for mankind as a whole and for society. To us, here, it is simply a duplication, by eye and hand, of what we observe in the case of ear and speech organs. In any case, the whole thing is essentially one more illustration of sensory-motor action; but it utterly transcends all older forms of action, because of what the mind can do, in its deepest recesses, with those words which its senses receive and its will reproduces.

If the process were only sensory-motor, like being struck and striking, it would not detain us, but it incidentally gives the mind the incomparable instrument called language, the instrument of thought, by which it conceives, discovers, imagines, creates We begin to see some significance in the Greek mystical use of Logos, or Word, as in the saying, "In the beginning was the Word". Words may often be feeble, foolish, empty, but they are the instrument, the indispensable instrument, and to some extent even the constructors, of thought, which is one of the supreme attributes, and is indeed the most nearly characteristic attribute, of man As Bacon said: "Men imagine that their reason governs words, while, in fact, words react upon the understanding." We do well, therefore, to study closely the cerebral apparatus of *speech*, or *language*, words which both literally refer to what is spoken, but which may here be used as referring to words spoken and heard, written and read.

This study is as near as we shall come to intelligence, if we add it to what we have already learned about memory and association. The brain does not provide us with any special structure or "center" for thought or intelligence. We cannot point to any lobe or convolution and say "that is the thinking center". The whole brain is involved in thinking; and when we come to examine the processes of thought or intelligence we see that they can be resolved into sensation, memory, association That, so to speak, is the dissection or anatomy of intelligence.

We cannot come upon it as a whole, in some corner of the brain, and we cannot claim for it the distinction of being something new, unprecedented, an extra, in the case of man. On the contrary, our analysis shows it to be a higher development of psychical facts, from sensation upwards, which are not peculiar to man. Any animal which can feel, remember, associate, is in some measure intelligent, which means that all animals, if not indeed all forms of life, including plants, are in some measure intelligent. The human intelligence is only the highest development of powers which are older than man On this point all evolutionists are agreed.

Speech only a higher form of intelligent animal behavior

Further, before we study the particular kind of sensory-motor behavior, feeling and response, which we call speech, and which is so characteristic of man, let us carefully observe that this, too, is only a higher development of ways in which intelligent behavior is illustrated among the lower animals. It is, indeed, a fair question whether there is a greater gap between the powers of understanding and expression by speech seen in a highly educated dog and a simpleton respectively than between the simpleton and a man of genius or talent, in language written or spoken. We merely play with words if we say that a dog, for instance, cannot speak because it does not speak English. If an animal makes certain sounds to convey certain meanings, and if, further, it has learned those sounds, and understands the sounds, such as words, made by human beings, in all essentials that animal has some measure of the mode of intelligent behavior which we call speech when it is illustrated in man.

The difference in speech between a man and a dog a question of degree

The differences between a dog or a parrot and a man are immense and potent, but they are differences in degree, not in kind. We have a larger vocabulary, a wider range in its use, a much more efficient mechanism of larynx, lower jaw and tongue for purposes of mere articulation, and sensory organs which are capable of recognizing and remembering far more and far more minute differences in sounds or in marks on paper, but all these assertions are comparative only. We therefore approach the exact physiology of human speech with due, but with no more than due, appreciation of its remarkable place in the wide scale of nature.

Speech is essentially a sensory-motor act, as we have seen, and so we begin by reviewing the facts of its sensory aspect, which we may suppose ourselves to have studied. We have defined the visual center in the occipital lobe of the brain, and the auditory center in the temporal lobe. Presumably, then, words are seen or heard in those centers, and there is no more to learn about them. But the facts are much more complicated. It is true, and it is not true, to say that words are so seen or heard They are there seen or heard, but they are not understood They are seen as marks, which mean no more than, probably, Arabic writing to the reader; or heard as sounds which mean no more than Arabic words. The sheer seeing or hearing must be done in these centers or nowhere, but they do no more If words are to be understood, if they are to mean anything, new centers must be educated. Words may be heard, remembered, repeated, as by a parrot, with a perfect sensory-motor mechanism, but that is only the imitation of intelligence, as much human speech may also be. If the process is to be true speech, truly intelligent, and capable of leading up to thought, the words seen or heard must be not only identified but understood.

The word-seeing brain-center developed by education

We find, accordingly, that there is a "word-seeing" or "word-perception" center in the brain, close to the visual center, but distinct from it. The visual center occupies the hindmost part of the cerebrum — the back of the occipital lobe. A little forward from it, only on the left side of the brain in right-handed persons, and *vice versa*, we find the "word-seeing" center, which is only developed by educa-

tion, though its capacity for such education is doubtless inborn Here, and here alone, all words seen are understood If it failed in your brain at this moment, on left or right side, according as you are right or left handed, and the left or right side of your brain is the "leading half", these words would still be seen as marks on paper, which you might even memorize and reproduce, but they would be just as if they were the characters of some language unknown to you You would be what we call "word-blind". That is why we said that it is true, and not true, that words are seen in the visual center; they are seen, but they are not seen as words. It need hardly be said that this applies to the reading of music or shorthand, as well as to ordinary language.

The word-seeing brain-center characteristic of man

This fact of the existence of a separate word-seeing or symbol-understanding center — for that is what it really is — could never be discovered except by the experiments of disease. It is a fact of man alone, though it may be that highly educated, highly educable animals may sometimes develop the beginnings of such a center; and it is demonstrated in cases where a tumor, fracture, hemorrhage, arterial blockage or some other injury has chanced to throw out of action this center alone. In such cases the patient sees but does not perceive the words in front of him We may add that the recognition of familiar faces follows the same laws, though probably a separate part of the brain, near the "visual cortex", is educated for the purpose. If the "visual cortex" itself be alone thrown out of action, of course there is an end of all vision.

The perceiving center, though entirely intact, has no material offered it for scrutiny and comprehension, for the patient is stone-blind. But if the perceiving center alone be affected, he sees the print indeed, as most of us see Arabic or Hindustani, and that is all. A similar injury in the "led half" of the brain, such as the right half in right-handed people, would produce no symptoms at all, so far as the evidence goes. It has not been educated for this special function It may be suggested, however, that the highest developments of language, in all its forms, may yet be proved to depend upon the education of the potential centers in both sides of the brain.

Forms of disease that affect the use of words

The technical name for any form of speech-failure, whether written or spoken speech, provided that it be due to the brain centers, and is not merely a defect of articulation, is *aphasia* Mere defects of speech like stammering, or indistinct utterance due to defective action, and especially defective coördination, of the organs of articulation, do not here concern us, and should not be called aphasia, so different is their real nature. True aphasia is perhaps the highest and subtlest study in the whole range of neurology, because it brings the pure neurologist, the student of the brain and nervous action, closest to the psychologist, the student of the mind. Many large volumes have been written upon the subject; and its special significance for us here is that only the study of aphasia can reveal to us the normal physiology of speech. It is the experiments of accident and disease, some of them very rare, which have just chanced to define the respective details They show that aphasia may take a host of different forms, and to each of these special technical names have been given. We need merely the English names; and we note, then, that what has just been described, regarding the presence of the word-understanding center, is derived from observation of cases of "word-blindness". Pure word-blindness is the description of those rare cases where this center has been thrown out of action, without any injury to the visual center or to any of its connections. In such cases, the person who could read can no longer do so, but if the words be spoken to him he knows their meanings at once. So specialized, in "cortical representation" — *i e.*, in allocation upon the *cortex cerebri* — are the individual portions of the universally distributed whole which we call intelligence.

The curious occurrence of word-deafness from disease

Passing now to the auditory center, precisely the same facts are found. The auditory or hearing center alone hears. No hearing is possible without it, and all subsequent recognition or understanding of what is heard must first wait upon the sheer hearing. Sometimes injury or disease destroys this center, and the result is partial deafness, or stone deafness if the centers on both sides of the brain were both destroyed. If, however, this pair of centers be intact, but damage be done to a small area of the cortex close above the auditory center, on the left side only in right-handed, and on the right side only in left-handed, persons, then, though hearing will be perfect, understanding of language will be gone. If the person has learned to read, he can still read. Anything scribbled "reaches his mind" at once, for the word-seeing center is as intact as the visual center itself. But the word-hearing center is not as intact as the auditory center, and the patient is, in short, a victim of "word-deafness". This name is not, perhaps, very accurate, but it conveys the required meaning. In this instance, also, the recorded cases are rare, for an injury or disease is not likely to destroy this tiny area without touching the auditory center which lies just beneath it, but we have quite sufficient evidence to establish the facts.

Are different areas of the brain educated by different languages?

It is practically certain that distinct areas exist, or are educated, in the process of learning different languages. They are not all jumbled together; and the same is probably true of written languages and the *reading-center*, for that is what the word-perception center may be called. And now, of course, we can state, in terms of the brain, the nature of the process which we call learning to read, or learning to understand, a language. The child which gradually associates meanings with sounds, so that it understands simple, often-repeated words, is developing the potential powers of its word-perception center. It does not require teaching to see. That is an elementary, native power of the visual center, marvelously developed during months of utter darkness, which responds to the light when first the eyes open upon the world

But the child requires teaching to read, because the association of certain sounds and certain meanings with certain designs, such as A or I, is not natural, but an artifice of man, and the child requires to form these artificial associations. Thus the central importance of association is again illustrated. We saw its importance for memory, and now we see its importance for intelligence. We have learned to associate a certain idea with the symbol I, another with the symbol O, and so on. This association is the basis of all written language. A brain of humble type cannot learn to this extent, because it has not the machinery of association. The vulture will see a letter O at a distance at which we see nothing, but its brain cannot understand the idea that O shall be pronounced as it is, and indicate what it does That requires more than sheer vision, however acute, and depends upon the special development of a brain area which is capable of that development — the education of an educable area of the *cortex cerebri*.

Our arbitrary alphabet a growth from pictures through symbolism

No doubt there is a degree to which the association is simplified, because O suggests, perhaps, the rounded mouth which pronounces it, the widely opened eye of surprise; and just as the form of the letter is derived from the open eye, so the form of the letter I is derived from that of "man the erect". The hieroglyphics of ancient Egypt and the symbols of the modern Chinese show us the growth of a symbolic alphabet from pictures; but now, though the associations were originally natural, so that O and I suggested their meaning, perhaps, they are almost wholly arbitrary. There is no reason why B and P and R should not be pronounced R and B and P. A system of arbitrary associations, which we call the alphabet, has been invented, with invaluable results; and learning to read means, primarily, learning the asso-

ciations between forms and sounds. The brain which cannot associate to this extent, like that of an imbecile, cannot learn to read, and the defect is rightly called a defect of intelligence Thus the essential nature of intelligence becomes apparent.

Its psychological basis is quite simple; but if only it reaches the degree of complexity of association which it reaches in man, it becomes an instrument of unlimited powers. The invention of the alphabet was, from this point of view, probably the greatest in history From it there followed not merely the possibility of writing things down and so retaining them indefinitely, but the much more important possibility of making ever more associations — the upshot of which is the boundless thought of man But for this you must have a system of association-symbols which can themselves be associated, so as to form words, the number of which can be indefinitely added to, and to each of which special meanings may be attached.

The greatest of all inventions, that opened the road to the infinite

Add a parallel arrangement of designs called numbers, and with the two we have the possibility of those products of intelligence which we call literature and mathematics. Their feature is that they are unlimited. Anyone may add to them "No one can set bounds to thought", whether the thought of the poet or of the mathematician. Yet a Shakespeare or Newton is not possible unless he be born into a civilization where this system of conventional associations has been elaborated, and unless he first masters them They are simple and humble things, but they condition infinite things. We see now why even a Shakespeare or a Newton has to *learn* Their native powers may be transcendent, their capacity of learning (which is making old associations) and of creating (which is making new associations) may be infinite, but no brain can be born with a knowledge of purely conventional associations like the meanings of words Only the brain may be born with an area which can master these associations when they are presented to it.

The vital importance of the sensory part of education

Before we pass on to the motor aspect of speech, by voice or pen, we must observe that this sensory half of it, which we have discussed, is by far the more important Everything depends upon it Failing the sensory education, no motor reproduction of words is possible. In a word, the greater part of education is sensory. No doubt the child requires to learn to talk as well as to understand. No doubt articulation is a delicate art, and few of us ever speak a foreign language "like a native" of any country but our own. But once one has learned to pronounce any language, little further education is there required. You might go to an elocutionist, perhaps, for a study of voice effects, but no more.

On the other hand, sensory education is endless. There are all the words in the dictionary. You could pronounce any of them, perhaps half a million, but you have only learned to know a few thousands Your future learning of language, the instrument of thought, is thus essentially sensory; you can say the word all right, if you have learned it, and if it "comes into your head" at the right moment, in thought or writing or speech, because it has formed the right associations with other words, and the ideas they stand for.

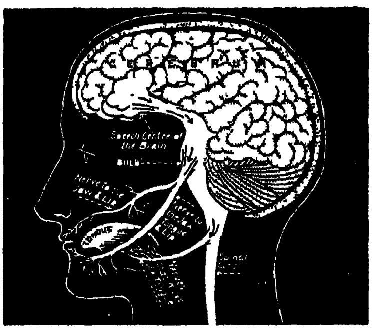
Not the pronunciation so much as the vocabulary the test of education

When we see how clearly the vital part of education is sensory, we realize how we judge the real education and intelligence of a man not by his pronunciation but by his vocabulary, by the number and fitness and variety of the words he uses. The motor details may interest us, showing whether English is his native tongue, and whether he learned to speak it in Boston or New York, or Denver or Detroit, or in Texas or Maine, but in the long run what matters is the words themselves The learning of them was sensory, and the power to learn and use them is really sensory and associative, and not motor.

In learning words, whether novel scientific words, such as, perhaps, *aphasia* in this

chapter, or in learning foreign words, or a line of poetry, we have all observed something which is of value besides the repetition which we have already referred to We find that the process of learning words is much facilitated by speaking them. Many of us can remember the spoken far better than the written word, some of us — a minority — remember the written word better. This depends largely or wholly on the bias of the brain, already discussed, as to whether we are more "visual" or "auditive". But it is quite certain that we shall remember best of all if the word be both spoken and written

Psychologists used to assert that the auditory memory of words is far deeper than the vision-memory — that the word-hearing center is much quicker and more



This diagram shows the speech center of the brain, known as Broca's area It controls the muscles of the lips, tongue and jaws

easily educable than the "reading" center, as we called it. Further inquiry shows that this is true of the majority, but not of all. In some, the reverse is the fact, and in some both centers seem equally educable. But for practical purposes everyone may confidently trust to the intentional employment of both centers for the best results. Lectures or remarks heard should be written and read A play of Shakespeare's, carefully read, should be also heard, properly spoken at the theater, or should be recited aloud by oneself. Hence a musician, in learning a score, may merely read it, but he will usually play it or hum it, at least in parts, as well Indeed, it is one of the arts of life, which all successful learners and creators know, to employ both of these "gateways of knowledge" in conjunction. As regards words, certainly, the student in these modern days of books should not ignore the importance of the auditory avenue It is *not* merely an avenue, but also a storehouse, having a definite brain area which holds associations between sounds and meanings

Reading and writing are all very wonderful, but listening and talking come first. The visual memory for the forms of objects is deep, but the visual memory from words is relatively shallow, as it is recent in our history. The difficulty of spelling correctly by sheer visual memory is familiar to many. But the auditory storehouse is of vast antiquity, dating back to man's earliest history So old, so deep, so radical to the structure of the mind, is the auditory storehouse that, though we may not have realized it, *we think in unspoken words.*

Any reader who has hitherto inclined to question the importance we have attributed to speech as the basis, almost or wholly, of intelligence must duly weigh this simple and familiar fact — that when we, or the Spencers, Darwins, Shakespeares, think, they do so in unspoken words, the memory of the sound of which is faintly but definitely aroused in the mind, doubtless through the help of the auditory word-center. This center, therefore (in the superior or uppermost of the three folds of the brain in the temporal lobe of the left side in a right-handed person), is the repository of those auditory word-images in terms of which we think.

Thus, the present writer is now thinking, and transcribing what he thinks. Except in moments of excitement, no word escapes his lips, but every word that is now flowing from his pen has just been faintly *heard*, has just been thought by means of unspoken sounds in his brain. The rest is mere mechanism; and he might just as well let the words he hears in the brain be uttered as sounds, and recorded by victrola or a secretary The process of writing, therefore, is not only really speech, but it depends on hearing. It depends upon the action of the auditory word-center; and every word which is written has been first heard, just as much as every note which the musician scribbles when he composes.

One does not *see* the sentence before it is written — one hears it. The same is true of reading or thinking, as every child illustrates with its moving lips, or as old people who persist in reading letters aloud, or in thinking aloud, show. When we read silently, as when we write silently, we faintly hear, within ourselves, the sounds of the words which we read Thus the auditory center comes in where it is not really needed One can read without it, as in the case of word-deaf persons, though the reading must be a strange process which does not go with a faint hearing of what we read; but when we who have normal brains read, the word-hearing center always contributes.

The preëminence of the word-hearing and music-comprehending centers

If any single center of the brain is to be placed above the rest, no doubt the word-hearing center, and its close neighbor, the music-comprehending center — by means of which (though not by their means alone) all thought and literature and oratory and music are conceived — must doubtless have that preeminence. If you are right-handed, the portion of the skull a little above your left ear covers the area in question These considerations provide the preliminary for a study of the deaf child and of deaf-mutism, the terrible association of dumbness with deafness, and the immense consequences of these defects for the whole mind. But we have no space here, and can only say that, compared with these people, and for reasons which the reader can now understand, happy are the children born blind

When we study the motor half of speech we learn that each center requires a second center, whether for talking or writing, as in the case of understanding words spoken or seen. The celebrated anthropologist Paul Broca, of Paris, discovered the "speech-center" so called, or Broca's area. We have already seen various absolutely essential centers, however, without which there could be no speech. What Broca found — and it was the first case of cerebral localization — was the center for the motor part of spoken speech.

Discovery of the part of the brain that holds the motor-memory of words

It lies in the lower part of the third left frontal convolution in right-handed persons, close to, but distinct from, the center which controls mere articulation.

Broca's area holds the motor-memory of words. If it be damaged, the memory of words is lost, though speech is unaffected. The patient will clearly repeat words after they are heard, but he cannot produce them for himself If no other part of the brain is affected, he can freely write his thoughts, but he cannot utter them. This, then, is the psychomotor center of speech-perception, by means of which we say what we mean to say, and identify it as we say it

Just similarly, the center for memory of words to be written is not the mere center for the movements of the hand, but lies close beside it. Damage of this center, for "psychomotor graphic perception", causes loss of the power to write an answer, though it can be spoken. Thus, if the reader's auditory and visual word-centers will hold so much, as doubtless they will, we may distinguish between two forms of aphasia — *aphemia*, loss of power to speak; and *agraphia*, loss of power to write. Either of these, of course, may be sensory or motor in origin, because speech and writing depend upon sensory as well as motor centers; and the sensory centers are involved in starting the motion, no less than in mere reception of something seen or heard.

The older and more natural centers, as we have seen, are those used in hearing and replying, which every child learns first. Writing and reading duplicate the apparatus. Granted that we have all of these in good order, and well stored with sensory memories and associations, so that we, perhaps, know seven languages, are we then certainly intelligent? Or is it possible to show oneself "a fool in seven languages"? Of course it is; and the fact indicates that these centers are not all.

We have not yet called upon the resources of any but a little of the back part of the frontal lobes.

The many centers of brain activity that act in concert

What about the first and second convolutions (from the front) of those lobes? Doubtless there we should find, if we could apply as simple tests as in aphasia, a number of centers, "ideational", "inhibitory", "associative", by means of which, for instance, we hold our tongues when shouted at, or suppress the cruel or superfluous jest, or "change the subject" The brain is, indeed, as we began by saying, none other than a sensory-motor machine, but it is a machine with a master. Stimulus and response, insult and retort, sensation and motion, do not inevitably always follow one another. Volition and inhibition or control remain. Thus we can arrest or we can initiate.

By means of these highest centers, which nevertheless must use the lower ones, as they the lower still, we are capable of those internal processes — rarer in most of us than most of us suppose — which we call thinking, starting trains of reasoning or sequences of imagination.

The fundamental place of words in the anatomy of intelligence

The formation of complex ideas, the power of steady attention or concentration upon certain subjects or chains of argument — all those higher powers by which alone memory and education and fluency and glibness can be made worth anything except to politicians — these are not explicable in terms of the centers we have discussed They reside in the frontal and parietal lobes of the brain in especial; and from them there must proceed innumerable fibers which have the powers of arrest and of initiation, and which pass to all the lower, more "mechanical" centers which we have already studied

Such, as nearly as we can arrive at it, is the structure or anatomy of the intelligence. Doubtless intelligence has more forms, more variations, than this account implies; and it is idle to deny that men "think" in musical sounds, in architectural lines, in colors, as they "think" in words. The processes involved are essentially the same. But words remain fundamental to all but these special and relatively rare forms of "intelligence". The total utility and value of the mind will depend upon the balance, no less than upon the individual development, of the various parts which we have described, and, above all, upon the highest centers, about which we had to be so vague If these upper centers fail, which they are always tending and threatening to do in the wisest of us, the words which we have gathered in the lower ones are liable to become as bad masters as they would have been good servants.

The dangerous potency of words in obscuring thoughts

This is the besetting danger of the intelligence, which Bacon, in his "Novum Organum", meant when he proceeded to discuss what he called "The Idols of the Market-Place", the most troublesome idols of all, which have entwined themselves round the Understanding from the association of words and names . . This has rendered philosophy and the sciences sophistical. Words define things by those broad lines which are most obvious to the vulgar mind; but when a more acute Understanding or more diligent observation is anxious to vary those lines, and to adapt them more accurately to nature, words oppose it. Hence the great and solemn disputes of learned men often end in controversies about words and names. . . . The Idols imposed upon the Understanding by words are of two kinds: they are either the names of things which have no existence . . . or they are the names of actual objects, but confused, badly defined, and hastily and irregularly abstracted from things."

The history of science and thought is full of illustrations of the dangerous potency of these indispensable creatures and creators of intelligence; and our analysis of the psychology of speech gives us some key to their power. But now we must proceed to something deeper, older, more powerful than intelligence — to those facts of instinct and emotion which largely use the intelligence as the mere instrument of their ends.

FURTHER PROBLEMS OF DIET

How the Human like any Physical Mechanism Obeys the Law of the Conservation of Energy

THE AMOUNT OF FOOD WE REQUIRE

WE are often warned by the physician against the danger of overeating, and probably every person has experienced the discomforts which result from such indiscretions. The human stomach has a limited capacity and the immediate penalty of overtaxing this capacity is pain from distention. But this is not the most serious consequence. Indeed it is possible to overeat without exciting any unpleasant sensations from the stomach. Acute indigestion with absorption of toxic products from incomplete preparation of the food for its uses beyond the alimentary wall is a more serious consequence, and this is often fatal More than this, however, the organs whose task it is to dispose of the food absorbed, clear it out of the blood every day after every meal, especially the liver, pancreas and kidney, may become overworked, and chronic disorders may result. The appetite, even in health, cannot be relied upon as an infallible guide, and in emergency it is always an obstruction to proper nourishment While still in health every person should take some thought regarding the quantity of food required by his body. Any person who is sufficiently interested can, in a few minutes, master the fundamental principles underlying the problem. Let us see what they are.

The human mechanism, like all purely physical mechanisms, obeys the law of the conservation of energy. This means that there is no form of physical energy in the body — whatever organ it may concern — which does not have its source in the potential energy of the food, just as truly as the mechanical work done by an automobile has its source in the potential energy of the fuel. It means further that the quantity of this energy as it leaves the body in the form of heat is exactly equal to the quantity which would be derived from the food as heat if this food were burned outside of the body. The successive steps by which this all-important law of human nutrition was established makes an interesting story of scientific progress.

Liebig, as early as 1842, had shown that all animal and vegetable substances contain carbon, hydrogen and oxygen, and fall into three classes: *fats* with more carbon than oxygen, *carbohydrates* containing hydrogen and oxygen in proportion to form water, and *proteins* containing nitrogen in addition to carbon, hydrogen and oxygen. Liebig soon saw that it would be quite possible to tell how much protein is used up in the animal body if the loss of nitrogen could be measured. Carl Voit, who had been a pupil of Liebig, acted on the suggestion of his master and proved the truth of this proposition. He also found that a full-grown animal or person is usually in "nitrogen equilibrium", a condition where just as much nitrogen is leaving the body in the excreta as is entering the body (in a given time) in the food. With sufficient other food (carbohydrates and fats) Voit found that nitrogen equilibrium could be maintained at a lower level than without these other foods.

Voit soon perceived that in order to know how much of the other foods were burned up it would be necessary to measure the output of carbon as well as nitro-

gen from the body. Since the greater part of the carbon issues from the body in the form of a gas (carbon dioxide), it was necessary to devise a means of measuring this gas. Then from the analysis of the other excreta for carbon, he would have the total loss of this element. With the help of Pettenkoffer, the physicist at the University of Munich, Voit set up in 1859 in his physiological laboratory an apparatus which was designed to measure the carbon dioxide. It consisted of a chamber large enough for a man to live in for twenty-four hours. The chamber was kept well ventilated by a current of air drawn through it and measured by means of a large gas meter driven by a water wheel. The air as it entered the chamber and again as it issued therefrom was sampled continuously and analyzed. Subtracting the amount of carbon dioxide of the ingoing air from that of the outgoing air the difference naturally was what came from the subject. The man in the chamber could lie down and sleep at night, could sit up and read or could do work such as turning a wheel during the day. He could also be given food through an opening in the side without disturbing the experiment. In short he could live a normal existence with such variations of rest and activity as a great many people habitually experience. Referring to the delight of himself and Pettenkoffer his associate at the success of their invention, Voit wrote many years after: "Imagine our sensations as the picture of the remarkable processes of the metabolism unrolled before our eyes, and a series of new facts became known to us." For having now the opportunity to measure the output of carbon as well as of nitrogen, they were soon able to measure how much fat, for example, was burned up in addition to protein. We need not stop for the details of their methods by which they calculated the results. The reader who is interested further can find these data elsewhere.

The important thing to note is that in that little laboratory was measured for the first time not yet seventy years ago the total metabolism (transformation of matter) in the human body. Knowing that foods consist of the same classes of substances (fats, carbohydrates and proteins) as the body itself contains, Voit now was able for the first time scientifically to supply the body just as much of these materials as it used up. He could place the body in carbon equilibrium as well as in nitrogen equilibrium and could study the factors which determine its level.

The metabolism of man expressed in terms of heat obtained by Rubner

The next significant step forward was taken by Rubner, who had been a pupil of Voit. Rubner was interested in the heat values of foods, and while still a pupil with Voit had shown that 100 grams of fat have the same heat value for the body as 232 grams of starch or 243 grams dried meat. Later he expressed these values as follows:

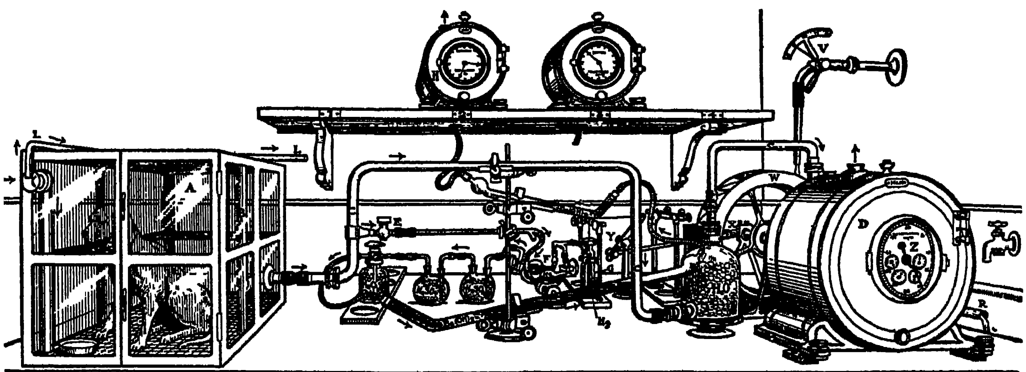
1 gram carbohydrate or protein will produce in the body 4.1 calories.

1 gram fat will produce in the body 9.3 calories

A calorie is the amount of heat necessary to raise 1 kilogram of water (2.2 pounds) one degree (Centigrade scale) in temperature. From the facts already brought to light by Voit and Pettenkoffer, Rubner now was able to express the metabolism of man in terms of heat. If a man excreted, for example, 15 grams of nitrogen in twenty-four hours and 200 grams of carbon, after calculating how much protein and fat, or protein, fat and carbohydrate this corresponded to, using his physiological heat values of foods, Rubner was able to say how much heat energy the man had developed in his body. But how was he to tell whether the results were correct; whether the heat values of the foods as determined outside the body were the same as when they were burned inside the body? It was obviously necessary to measure the heat production of the body itself. This led to the first successful animal calorimeter. It was large enough for a medium-sized dog and was erected by Rubner in his laboratory at Marburg. The instrument was at the same time a respiration apparatus built on the same principle as the Voit-Pettenkoffer machine.

The chamber, however, was surrounded by water so that the heat given off by the animal's body could be measured in calories. By means of this instrument, built largely with his own hands, Rubner was able to demonstrate the applicability of the law of conservation of energy to the animal body, for as the result of many experiments he found that the total heat as measured agreed perfectly with the heat as calculated from the known metabolism of foods by the use of the physiological heat values of foods. Rubner's final demonstration of this law was published in 1893. A few years later Atwater, the American chemist, undertook, in company with the physicist Rosa, the construction of a respiration calorimeter large enough for a man. With financial assistance from the U. S. Department of Agriculture it was set up at Middletown, Conn., and after many years of experimentation it successfully demonstrated, to the same degree of accuracy which Rubner had attained, the applicability of the same laws to the human body. Atwater and his associates went further, however, and proved that the law holds even when muscular work is being done. The subject in these experiments rode a stationary bicycle so arranged that by means of a magnetic brake the rider could be made to do any amount of muscular work desired. The external work was transformed by the brake and other forms of friction into heat and was measured by the calorimeter. The extra metabolism was also recorded in the elimination of more carbon dioxide and in the measurement of more free heat.

Thus was established the scientific basis for such knowledge as we have today of the fundamental needs of man as a pure mechanism. The same lines of investigation have now been greatly extended by several groups of scientists centered about the following as leaders: Zuntz at Berlin, Tigerstedt at Helsingfors, Hasselbalch at Copenhagen, Tangl at Budapest, and Armsby, Benedict and Lusk in America. The American work both in quality and quantity is the equal of any in the world. The respiration calorimeter begun by Atwater and Rosa was greatly improved by Benedict at the nutrition laboratory of the Carnegie Institute at Boston and by H. B. Williams working for Lusk at the Cornell University Medical College in New York. The latest form of the apparatus is in use at



From Tigerstedt's *Textbook of Human Physiology*, D. Appleton & Co., N. Y.

THE SMALLER RESPIRATION APPARATUS OF PETTENKOFFER AND VOIT

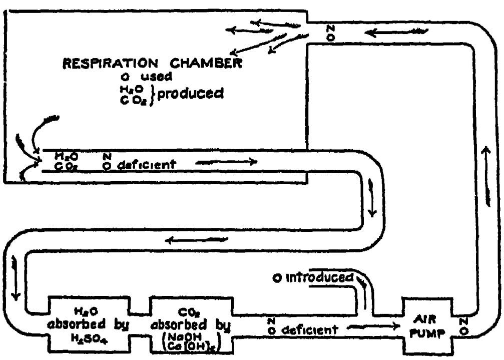
Air enters the cage, *A*, at the upper left-hand corner. It is drawn out through openings in the tube *B* (so spaced as to insure thorough diffusion) through the tube, *C*, and the large H_2O flask, where it is saturated with moisture, to the gas meter, *D*, where it is measured. The meter is driven by a water wheel, *W*, rotated at a uniform rate of speed by a constant head of water pressure, *V*. At *E* a side tube leads off from *C* conveying a sample of cage air for analysis. This air is drawn through a mercury valve, *F*, by means of the mercury pump, *G*. The latter is operated by the mechanism, *X*, *Y*, connected with the water wheel. From the valve, *F*, this air passes through two H_2SO_4 flasks and is then saturated with moisture so as to prevent loss of water from the $Ba(OH)_2$ tubes. Of course the air as it leaves the $Ba(OH)_2$ tubes is saturated with moisture, and is measured by the small gas meter, *H*, just as in the case of the large meter, while in this saturated condition. A duplicate sample is led off at the same time through another branch of the tube, *E*, and through another system of vessels to the gas meter at 3. Through the branches of the tube, *L*, duplicate samples of the air which enters the cage are drawn in the same manner to similar valves, and then through similar vessels and tubes to meters placed at 1 and 4.

the Bellevue Hospital in New York for the study of metabolism and nutrition requirements in disease.

The more important principles of energy metabolism which have been established by these workers are the following:

1. *The amount of heat produced by the body at rest is proportional not to its weight but to its surface area* (Rubner). This follows from the fact that the body loses heat by radiation and conduction in proportion to surface. Hence also the food requirement for the production of heat is proportional to the surface.

2. *The energy production is least when the body is at rest, is fasting and is kept warm.* It is increased therefore by muscular activity, by the action of food and by a low



SCHEMA OF THE SYSTEM OF VENTILATION EMPLOYED IN BENEDICT'S MODIFICATION OF THE ATWATER-ROSA CALORIMETER

The respiration chamber is the inner chamber of the calorimeter

environmental temperature. This law in each of its parts was recognized by Lavoisier, who discovered the cause of combustion both inside and outside the animal body. It has been demonstrated beyond doubt as regards the influence of work and food by many observers, but not yet satisfactorily as regards the influence of cold independently of muscular motions.

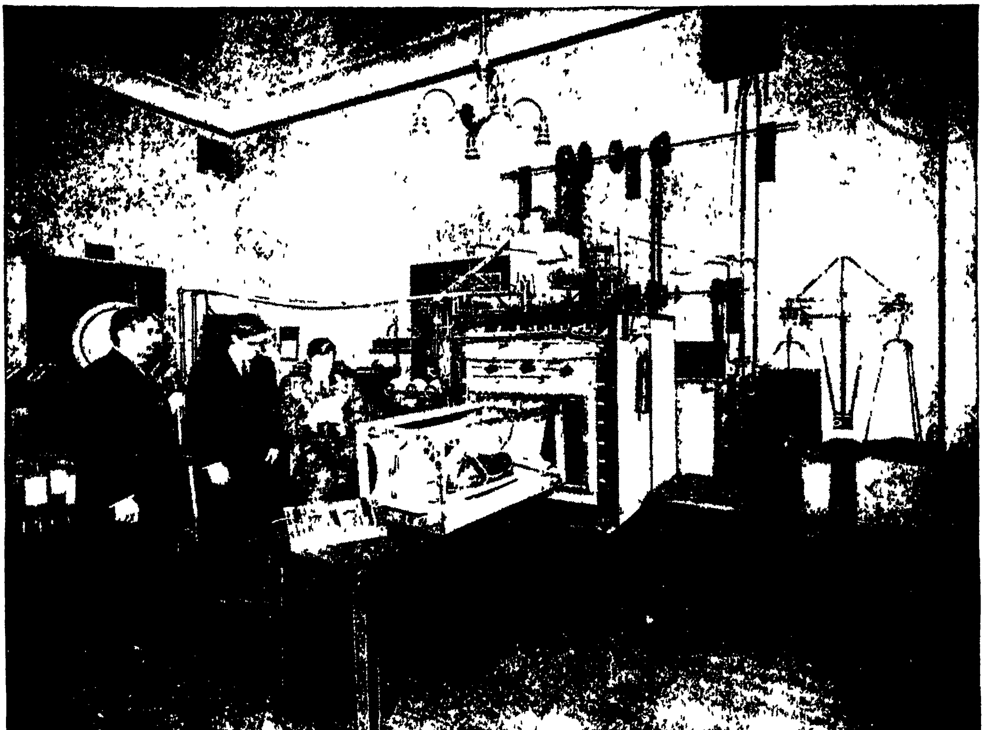
3. *The resting energy metabolism per unit of surface varies with age.* Immediately after birth, before the heat regulating mechanism has become fully developed, it is very low. It advances rapidly, however, during the first year and somewhere between one and two years of age reaches its maximum. From this point on, with the exception of a temporary acceleration at the time of puberty, it declines slowly but steadily to old age.

4. *Of the different foods protein raises the energy metabolism most, fat next and carbohydrates least.* From this basic principle we can readily understand why meats, especially fat meat, can be relished only in cold weather, while lighter foods consisting largely of carbohydrates are chosen in hot weather.

These are perhaps all of the basic principles of energy metabolism it is necessary for a person in health to know. Let us see how they may be applied practically.

How to estimate energy supply at home

Very few individuals out of the total population have or ever will have their energy requirement measured directly with a calorimeter; but a sufficient number of experiments have been performed on healthy subjects to make it perfectly certain that individual variations for any given age group are not over 10 per cent from the mean. The average utilization of energy *under minimal conditions* is about 14 calories per pound per twenty-four hours, or for a man of average weight (154 pounds) 2150 calories. We shall not miss it far if we should say that this person sitting up instead of lying quietly in bed would use, say, 1 calorie per pound more (2300), and if he digests three good meals a day he would use an additional calorie per pound (2450). If he goes about his business, which we will suppose involves light muscular work, such as typewriting, he uses about 25 calories per hour for this work, or in eight hours 200 calories, making a total of 2650 calories or 17 calories per pound. If a person's work requires him to walk about all day instead of sitting still and using his arms, he of course does the work of carrying his body, to say nothing of other things he may carry, and the allowance must be three or four times as great as in the case of typewriting. A soldier on the march walking less than three miles an hour has been found to use 160 calories per hour for the muscular work alone. Most occupations which involve walking are less exacting because there are frequent



From the *Medical Record*

RESPIRATION CALORIMETER BUILT FOR OBSERVATIONS ON THE DOG, AT CORNELL UNIVERSITY MEDICAL COLLEGE

The dog, wearing a bandage which holds a rectal thermometer in place, is shown lying on a cot suspended from a frame which may at any time be slid into the open chamber of the calorimeter. This accomplished, the front is then sealed. The animal respires within the chamber, the water and carbonic acid which he eliminates are removed by circulating the air through absorbing chemicals, and fresh oxygen is admitted automatically to replace the oxygen absorbed by the animal. Four people are constantly employed during the experiment. The heat produced by the dog is removed and measured by a current of water flowing through a system of pipes within the calorimeter.

rest periods. So if we were to allow 75 calories an hour it would probably supply the extra energy requirement over that of complete muscular rest, for, say, a pretty active salesman. His total intake in three meals, if he is of average weight, would be, therefore, some 400 calories more than that of an office worker, say a bookkeeper.

The simplest method yet devised for keeping account of the energy supply in one's diet is that devised by Professor Irving Fisher of Yale University. The idea underlying it is to do away with intricate calculations by familiarizing one's self with the amount of each article of food, as served at the table, which yields 100 calories of energy. This he has called the "standard portion". All that is required is a reliable table of foods and a good pair of scales, or still better, a good balance. Scales often go wrong, but a balance with good pointer will always weigh accurately provided the weights be kept clean. An outlay of ten to fifteen dollars for a satisfactory balance is amply justified by what the housekeeper can learn in one year of the value of different foods in connection with energy supply.

By writing to the Superintendent of Documents at Washington the student can obtain a list of publications on foods, which can be supplied by the Government, with prices quoted and year of publication. Bulletin No. 28 of the United States Department of Agriculture, published in 1906, price five cents, entitled "Composition of American Foods", by Atwater and Bryant, contains nearly all the information required. A little book entitled "Feeding the Family", by Mary Swartz Rose, also contains these tables fully worked out so as to be of immediate use.

SAMPLE DIET FOR A SALESMAN OF AVERAGE WEIGHT

Breakfast

	Portions	Protein Calories
1 small orange	½	3
2 shredded wheat biscuit	2	26
Vienna roll and butter	2	12
1 egg, soft fried or poached	1	32
2 thin slices bacon	1	6
Coffee, cream, sugar	½	2.5
Total, 700 calories		81.5

Luncheon

Ordinary serving of beef stew	2	24
Tomato or beet salad with dressing	1½	15
2 slices bread and butter	3	28
Apple tapioca pudding, large	2	2
Cocoa, cream, sugar	1	4
Total, 950 calories		73

Dinner

Cream of celery soup	½	8
Ordinary serving roast lamb	3	120
2 baked potatoes	2	22
Side dish green peas	2	50
Salad, mayonnaise dressing	1	0
2 slices bread and butter	3	28
Milk custard	1	26
Small piece sponge cake	1	7
Total, 1350 calories		261

Grand total, 3000 calories, with 13% protein calories

SAMPLE DIET FOR AN OFFICE WORKER OF AVERAGE WEIGHT

Breakfast

	Portions	Protein Calories
1 small orange	½	3
Large serving oatmeal	1	18
Cream and sugar	2	2 5
2 slices dry toast	2	28
Ordinary serving butter	1	.5
2 eggs, soft boiled	2	64
Cup coffee	0	0
Cream and sugar	½	2 5
Total, 800 calories		118 5

Luncheon

2 small tomato and lettuce sandwiches	2	28
1 large glass whole milk	2	38
1 piece apple pie	3	15
Total, 700 calories		81

Dinner

Plate of bouillon	0	0
Small serving rib roast	2	50
2 small sweet potatoes with butter	3	20
Ordinary serving sweet corn	1	16
Salad with teaspoon olive oil	1	0
Ordinary serving rice pudding with cream	2½	20
Bread and butter	2	18
Demi-tasse black coffee	0	0
Total, 1150 calories		124

Grand total, 2650 calories, with 12% protein calories

The mechanical efficiency of the human body

If the reader has ever climbed to the top of the Washington Monument, he is probably willing to offer his experience as an example of hard muscular work. If at the same time his weight was 154 pounds, he did 11,620 kilogrammeters of work (1 kilogrammeter is the amount of work expended in lifting 1 kilogram or 2.2 pounds against the force of gravity, 1 meter). How much food did you use up in doing this piece of muscular work? Most of us, perhaps, would say at least several pounds of meat. It will be a source of surprise and perhaps of disappointment to learn that if you were doing the work again you could cover your whole requirement for the work alone by adding not to exceed 1 quarter pound of meat, if you insisted on having the extra energy in that form, or three lumps of sugar, or a dish of cornstarch pudding, or a small baked potato, to your regular diet.

The human body must indeed be a good machine to lift itself 550 feet straight up on the energy of three lumps of sugar! If, however, it were a perfect machine, able to convert all of the potential energy of the food into work, it would require only one lump instead of three. There is an amazing amount of energy locked up in a little bit of food. At the same time we have no right to complain of the inability of the body to convert all this energy into work, for the body is nearly twice as efficient as the best steam engine which has ever been made. It requires a very good engine indeed to convert 15 per cent of the fuel energy into mechanical work; the other 85 per cent escapes into the air as heat and is irrecoverably lost. The human body at best, *i.e.* in lifting itself by its legs, can convert about 33⅓ per cent of the fuel energy of the food into work and leave the other 66⅔ per cent as heat. At other forms of work the efficiency is often not over 20 per cent. In the case of the body, however, the free

heat is not entirely lost. If the climb above mentioned were made in very cold weather, the climber would be at least comfortably warm when he reached the top of the monument The heat which made him warm would come from the other two lumps of sugar or from the $66\frac{2}{3}$ per cent. If it were a warm day the extra heat would be an inconvenience, rather than a comfort, and he would do all he could to facilitate its escape

To state the matter generally, we may say that in order to do any given piece of muscular work we are obliged to burn at least three times as much food as really contains the necessary energy. One-third of the energy set free goes over into work energy and the other two-thirds takes the form of heat which in cold weather may be used to keep the body warm, but in warm weather must be got rid of by sweating to prevent the body from warming up to a fever.

Why we eat so much

Seeing that it requires so little food to furnish the energy for muscular work, why is it that we eat so much? The answer to this question is that a great deal of food must be burned merely to keep the body warmed to the point of 98° F. all the time. Let us see how this is accomplished and then we shall return to the subject of work. Up in the base of the brain is a heat regulator. When you go out on a cold day, and find that you are not dressed warmly enough, the cold stimulates your skin. The nerves running from the skin convey this stimulus to the regulator, and the regulator gives out impulses which cause you to shiver. Shivering is muscular work solely for the purpose of producing heat. In order to stop it all that anybody needs to do is to substitute another kind of muscular work like walking rapidly or running. Of course you can prevent shivering also by putting on a heavy coat — a fur coat if you have one. This keeps the heat in for you just as it did for the animal who once wore it.

There are two ways, then, of offsetting the effect of cold: one is to increase the heat production by doing muscular work, the other is to decrease heat loss by wearing clothing of non-conducting material. Those who can afford such — woolens or fur — and have no artificial heat, must produce the heat by muscular work in their own bodies. If the weather is not extreme, they are better off, physically speaking, for so doing. Naturally the supply of food for this purpose must be plentiful.

People who can afford it, as a rule, adopt the other method — that of surrounding their bodies with non-conducting materials or warm air. They should remember that when they do this extra food is not needed. Precisely because they do not remember this, the well-to-do are inclined to overeat and are obliged, as a consequence, to store within their bodies as fat the materials which they do not burn up. While a certain amount of body fat is a good sign of physical well-being, physical fitness for efficient work is by no means proportional to the amount of fat. It would be better if well-to-do people generally cultivated some capacity for increasing their heat production. The ability to oxidize material readily is a safeguard against accumulation of many toxic substances.

To return now to the subject of work, it will be clear that the requirements of the body for muscular labor in winter will depend on whether a person works outdoors or in the house. Lumbermen who work in the north woods in the winter probably require more food than any other class of laborers. At the opposite extreme, so far as external conditions are concerned, stand the men who work in factories, beside furnaces, etc. Their muscular work may be just as heavy as that of the lumberman, but their bodies are kept warm by artificial heat; hence the heat need not be developed within. The problem for them, as for ordinary outdoor laborers in hot weather, is rather that of removing the extra heat.

Between these two extremes, naturally, are people who are subjected to conditions of all degrees of severity. It is impossible to describe a day's dietary which will fit all of them. We select a truckman and a foundryman of average weight.

The former we suppose not only does the heavy muscular work of lifting cases and such things, but is exposed to cold winds and rains The latter does heavy work, but is kept warm at his task.

Another important point is the kind of food best adapted to the winter season. A person who follows his natural craving will find himself eating more meat, especially more fat meat, in winter than in summer. This is not merely because fat contains more energy for the same weight than starchy foods, but because foods rich in protein and fat stimulate the processes of combustion by which heat is produced. For example, a day's diet consisting of nothing but lean meat would increase the heat production by about 30 per cent The same diet, consisting exclusively of starchy foods, would increase it by only about 5 per cent. This is the reason that laborers in the open crave meats more than do those who work indoors.

SAMPLE DIET FOR A TRUCKMAN

FULL DAILY SUPPLY OF ENERGY FOR A TRUCKMAN OF AVERAGE WEIGHT

	Portions	Protein Calories
Breakfast		
3 wheat cakes with maple sirup	4	45
2 small chops (pork or lamb)	2	36
French fried potatoes	2	22
2 slices of bread	2	28
With butter	1	0
1 cup coffee	0	0
Cream and sugar	½	2 5
Total, 1150 calories		133 5
Luncheon		
Plate of baked beans	3	63
With small piece fat pork	2	28
4 slices bread and butter	6	56
Rice pudding	2	16
Cup of tea with sugar	½	0
Total, 1350 calories		163
Dinner		
Large plate cream of celery soup	1	16
Large serving rump roast beef	3	180
Large serving macaroni and cheese	3	53
2 large tablespoons creamed mashed potatoes	2	20
Side dish stewed tomatoes	½	7
Bread (2) and butter (1)	3	28
2 small baked apples	2	4
With cream and sugar	1	0
Ordinary slice sponge cake	2	14
Total, 1750 calories		322
Grand total, 4250 calories with 14 5% protein calories		618.5

SAMPLE DIET FOR A FOUNDRY WORKER

FULL DAILY SUPPLY OF ENERGY FOR A FOUNDRY WORKER OF AVERAGE WEIGHT

	Portions	Protein Calories
Breakfast		
Large serving oatmeal	1	18
Cream and sugar	1	2 5
2 slices dry toast	2	26
Butter	1	0 5
Large serving ham	2	66
2 eggs	2	64
1 cup coffee, cream and sugar	½	2 5
Total, 950 calories		179 5
Luncheon		
3 sandwiches	6	56
With cold boiled ham (cut thin)	1	28
2 crullers	4	24
1 pint whole milk	3	57
Total, 1400 calories		165
Dinner		
Clear tomato soup	0	0
Large serving sirloin beef	2	60
Large serving rice	2	20
2 large sweet potatoes	4	24
Side dish stewed onions	1	12
3 slices bread and butter	4	42
1 dish tapioca pudding	2	0
Cup tea with sugar	½	1
Total, 1550 calories		159
Grand total, 3900 calories with 13% protein calories		503 5

Energy requirements of brain workers

In the previous chapter we have learned that there is no single brain-building food. Any brain worker may be certain of having the necessary materials to replenish the wear and tear from his mental machinery if he eats a varied dietary and one which is adequate in energy.

Brain work, like all forms of activity, is accompanied by increased oxidization in that organ, but the brain is so small compared with the whole body or with the muscles that the severest work one is capable of doing with the brain does not increase the total expenditure of energy more than ten per cent. Besides, the most powerful concentration of the mind is usually accompanied by a compensatory diminution of energy expenditure in other organs. For example, the utmost concentration is commonly accompanied by complete quietude of the voluntary muscles, and we all know that it is difficult to secure the best results mentally on a full stomach.

The energy requirements of the brain worker, therefore, are those of an office worker. The master engineeer who solves the most intricate problems, or the statesman who plans a world empire, does not expend more physical energy in the elaboration of these plans than does the stenographer (of equal weight) who takes dictation. Brain efficiency cannot be gauged in heat units.

Food requirements of mother and child

From an extensive study of the natural dietaries of a large number of American families it has been found that in the average family the energy consumption of the mother is about eight-tenths that of the father. Of course there are wide variations from this rule, as when the mother is actually larger and stronger than the father; but taking average weights for the American man as well as for his wife, and assuming that the wife does, if not all, at least a large share of the housework herself, the estimate of eight-tenths is probably a safe one. This means that if we allow an energy supply of 30 standard portions a day for the man of the family, that of his wife should be about 24 portions.

For a woman of average weight (130 pounds) this would be about 18 5 calories per pound of actual body weight. For a woman whose work is done for her by servants the requirement would probably be not over 21 standard portions, or 16 calories per pound.

This estimate applies to the energy requirements only of the woman whose maternal functions are in abeyance. Suppose those functions are active, how are the nutritive requirements affected? This relationship of the maternal functions to food requirements is a question in which the writer has been particularly interested for several years. How much energy is expended in the prenatal development of the child? What is the energy requirement of the newborn and of its nursing mother? Manifestly these are extremely important matters, whether we look at them from the standpoint of the mother or of the child.

On the mother's side the ideal, we can readily see, is such a balance of the nutritive processes that when the child is born, and again when he is weaned, the mother's body shall be at least as well off as it was before the new nutritive obligations were assumed In many instances, happily, the mother's bodily welfare is greatly enhanced by the change. The presence of an actively growing embryo stimulates the assimilative powers of the maternal tissues, and the mother actually grows along with her offspring. In other instances the benefit is merely one of accumulated fat. The mother becomes heavier without becoming stronger. Exceptionally the mother may find herself weaker and less fit for her ordinary tasks when the child is born or weaned, than before conception.

It has been shown very conclusively that the food requirements of the developing child, or, we may better say, of the mother's body on behalf of the developing child, before the end of the fourth month (sixteenth week) are negligible. The embryo up to this time is so small that its entire mass might be formed from the substance of a single meal. The energy required to maintain its temperature at the same level as that of the mother is also quite negligible.

From the beginning of the fifth month on, development is more and more rapid, and it is at this time that the mother's body begins to increase perceptibly in size. At this time also the appetite normally increases, until in the eighth and ninth calendar months it becomes at times perfectly stupendous. Here is where another word of caution must be spoken. A mother who is active and at the same time pretty heavy, may easily eat too much. A simple calculation will suffice to show that the energy requirements are not so enormously large. It is very rare indeed for the child at birth to weigh one-tenth as much as the mother. It is a good-sized child which weighs one-twelfth as much, the average being one-fourteenth. We shall see presently that a sleeping infant may lose as much as two and one-half times as much heat per pound as the mother

beside it in bed. If we suppose that the unborn child requires as much as the newborn, the total increase in energy requirement would not be more than one-fifth (two and one-half times one-twelfth) or 20 per cent of the mother's usual supply A mother whose everyday needs then were met by 2400 calories of energy would, in the last weeks preceding her confinement, require about 2880 calories, or say 3000, to be on the safe side. It turns out, then, that a mother of average weight and her babe together may require about the same amount as a father of average weight.

The extra quantity of energy may well be supplied in the form of rich milk between meals. There is good reason for thinking that the mother's body utilizes frequent small meals on behalf of the developing child to better advantage than it does a few large meals. Eggs may be added, and are best taken raw with the milk The time to prepare for breast feeding is within the last month preceding birth. At this time the mother's food should not only be plentiful, but of the most wholesome quality. Rich milk is better than meat; the bread should be coarse; high flavors should be avoided.

Baby's heat requirements

By the time the child is a year old its requirement is already four-tenths that of the mother; that is, if her basal requirement is 2400 calories, the child's is now about 960. Investigations which the writer inaugurated a few years ago have resulted in showing that the total energy requirement of mother and child just after birth is almost exactly the same as the total requirement just before birth. Not all the extra energy just before birth is used by the unborn child itself; a part of it is expended by the maternal organs which harbor and nourish the child.

But when the child begins a more independent life, breathing for himself, eating and digesting his own food, and maintaining his own temperature, the increase which his own requirements undergo is just equal to that portion of the energy which before birth was expended for him by the mother.

The result is that while the baby has suddenly assumed functions which are entirely new and very exacting from the point of view of his own little organism, the demand upon the mother's resources, now that she must nourish him through her breasts instead of through her circulation, is not materially increased. The extra energy which she delivers to the child the first day after birth, supposing the milk were to come at once, would scarcely be distinguishable from the amount which she expended for him the day before.

We are accustomed to think of a baby's stomach as a very delicate organ compared with the adult stomach, and so it is in the sense that it has a very limited tolerance for different kinds of food But, measured in relation to the weight of his body, a baby's digestive powers are at least three times as strong as those of an adult. There are two reasons for this: first, an infant must digest food for growth as well as for maintenance of his body; and, second, he requires very much more in proportion to his weight merely for maintenance than does an adult Heat is lost, as we have seen, by radiation and conduction through the skin Hence the more skin surface a person has in proportion to the weight the greater will be his heat loss in a unit of time In health the body of the baby and the body of its mother have the same temperature, or nearly so. If exposed to the same external temperature, the baby would lose heat much more rapidly than its mother; hence, in order to make good this loss it must burn more food in proportion to its weight.

From calorimetric studies it has been found that a sleeping infant from one to two weeks old gives off in twenty-four hours from 30 to 35 calories of heat per pound. A grown person under the same circumstances gives off less than half as much. In one series of observations it was found the babies asleep in bed beside their mothers, who were awake, gave off almost exactly two and one-half times as much heat per pound as did their mothers. It is evident from this comparison how necessary it is for the baby to have an adequate supply of energy.

AUTHOR'S RESPIRATION INCUBATOR FOR THE STUDY OF FOOD REQUIREMENTS IN THE BABY

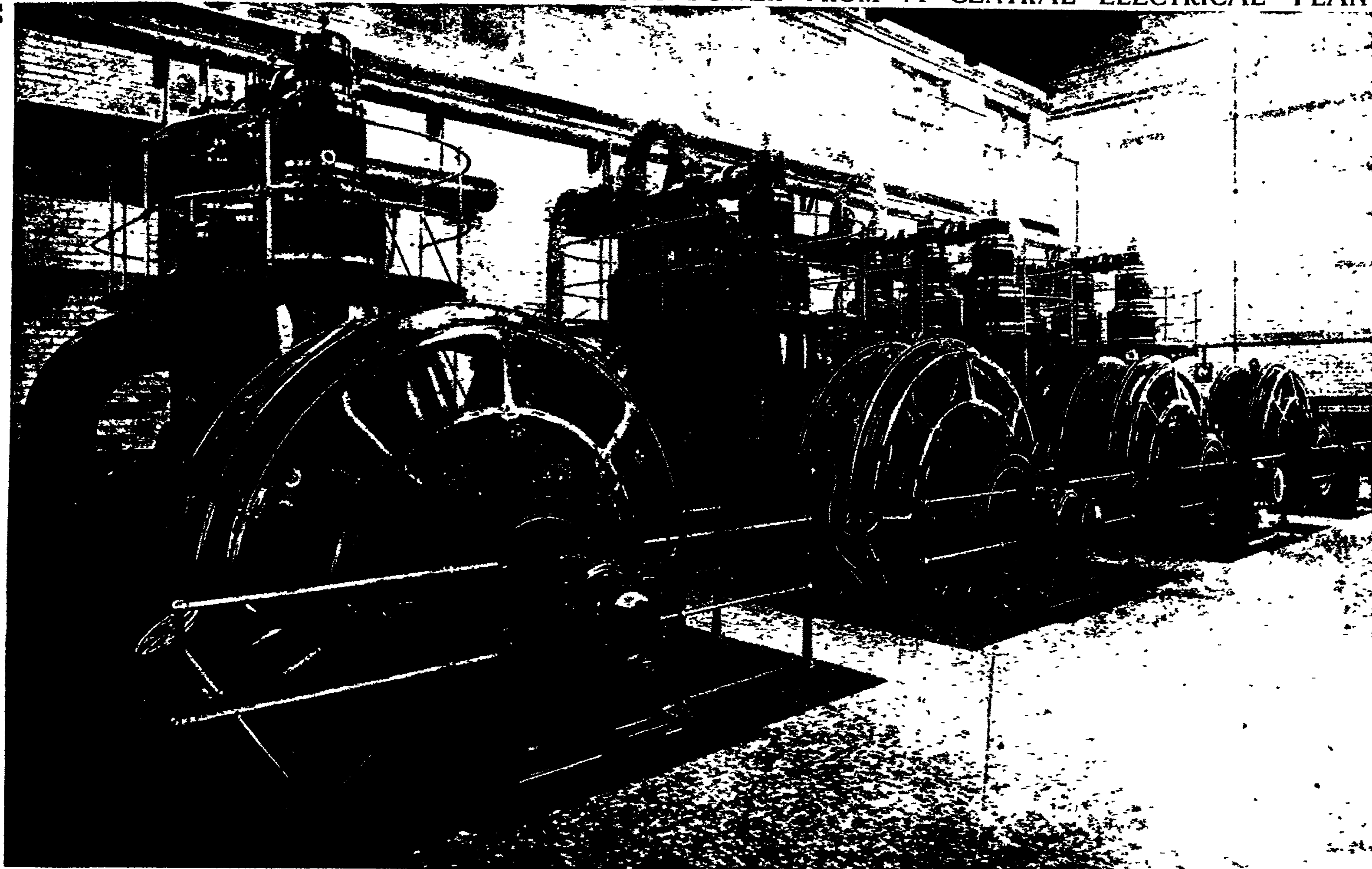
The child lies on a bed and sleeps. The pulse is recorded by means of a cuff around the child's leg and the number of respirations by means of a small instrument attached to the child's chest. The rubber tube connections pass through the walls of the chamber and transmit the waves of air to recording instruments placed on top of the incubator. The child remains in the chamber about two hours, or the duration of a good nap

So long as the baby is well and the mother's milk is satisfactory, the baby's appetite can usually be trusted to gage the amount of food to be taken. In fact, it is surprising how accurately the baby will measure with its stomach the calculated requirement. In one case the calculated requirement for twenty-four hours was 18 ounces of the mother's milk, which was being analyzed at the time. By weighing the baby just before and just after nursing each time we found that he had taken altogether in the twenty-four hours 18½ ounces.

Courtesy A. Vivian Mansell & Co.

"THE NEW ARRIVAL", BY WALTER LANGLEY

FEEDING ALL PARTS OF A FACTORY WITH POWER FROM A CENTRAL ELECTRICAL PLANT



AN ELECTRICAL INSTALLATION THAT DISTRIBUTES POWER TO THE MACHINERY OF A MANUFACTORY WITHOUT NEED OF SHAFTING OR BELTS

THE NEW ELECTRIC AGE

The Leading Part that Electricity Plays in Modern Civilization

THE UNIVERSAL SERVANT OF MANKIND

AT some time or other, every youthful reader of the Arabian Nights has doubtless been possessed with the vain hope that he might some day find Aladdin's wonderful lamp, and by rubbing it cause an all-powerful genie to appear, exclaiming, "What do you desire? I am ready to obey you as your slave." Maturer minds during the past century have perhaps discovered the lost lamp in a new form; a rival, at least, of Aladdin's genie has materialized to serve the commands of all civilized nations. The modern genie is called "electricity", and he is instantly summoned, ready to undertake the tasks of all those who turn an electric switch or push a button. Scientific discovery has thus transmuted fiction into fact, and has fettered the new slave so completely that he can never escape.

The use of electricity has become so closely interwoven with modern life and we have become so accustomed to its influence that its effect upon the existing state of civilization cannot be easily estimated. One of the first achievements of electricity was that of abridging space. A century ago, war might have broken out in Europe without becoming known to the inhabitants of the United States for weeks, perhaps months. The telegraphic transmission of intelligence through our ocean cables makes the daily news of London, of Paris and of Berlin appear almost simultaneously in New York, in Chicago or in San Francisco. Electricity has thus cemented the bonds of international interest and uprooted the physical barriers which fomented discord and misunderstanding between nations. International trade, as well as diplomatic intercourse, has been negotiated as easily as between neighboring cities. The wireless telegraph has, moreover, not only connected continent with continent but united every ship at sea with either continent and with every other ship at sea. The land line, the ocean cable and the wireless telegraph have brought the whole world to our door; the thoughts of an individual may be flashed into every town and hamlet, and the response returned as quickly.

Fifty years ago, conversation between individuals living miles apart was impossible. It was necessary for one to travel the intervening distance to place himself in the presence of another before a conversation could be carried on. The telephone has bridged this distance so that we may converse at length with a person located anywhere within reach of its great network of wires stretching across the continents into every city, town and hamlet.

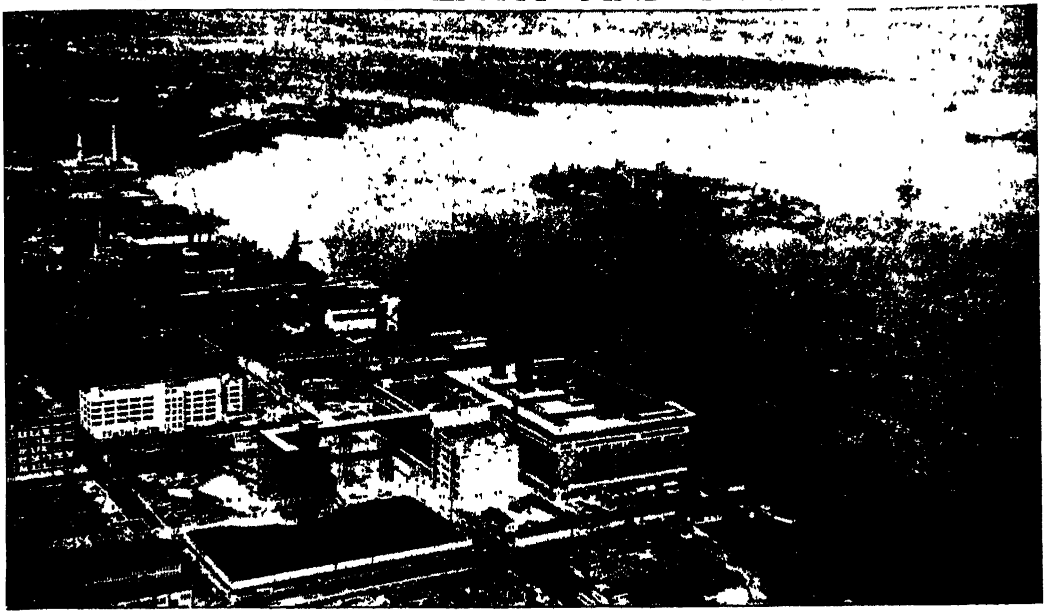
While the time and expense saved by transcontinental and interurban messages is vast, it is exceeded by that saved in the multitude of telephonic communications carried on in our cities and towns. The telephone has contributed greatly to the mitigation of congestion in our large cities by making it unnecessary for offices, salesrooms and factories to be located within a short distance of each other, since business can be transacted as well if they are located in different parts of the city. The lofty office building owes its existence in part to the telephone, which keeps the occupants of any office in touch with any other office in the building or outside it.

Transmission of intelligence by means of electricity reached its highest development not long ago when a man in Washington spoke simultaneously to a man in Paris and another in Honolulu without using the customary connecting wires. Aladdin himself could not have demanded a greater task of his powerful genie. With the advent of the wireless telephone, passengers on ships at sea may converse as easily with friends on shore as if located in the same building. The transmission of sound or articulated words through the medium of electricity has been extended from the few hundred yards — familiar to our forefathers — to thousands of miles; speech of man which in the nineteenth century bridged only our smallest rivers is now made to carry across the broad ocean or to jump between the continental shores. It only remains for the scientists of the twentieth century to develop the established principle of electric sound propagation to the end that oral communication may be easily established between any two earthly inhabitants however far apart, and without great expense.

The servitude of electricity to man and its effect upon civilization perhaps is no more strikingly illustrated than in its use as a medium in the transmission of energy. Man from time immemorial has made use of other sources than human energy; the use of animal energy dates back to antiquity, and we have evidence of the early use of the energy of falling water. In every instance, however, the point of application of the energy and its source was by necessity coincident The water-wheel and the grist-mill of the ancients were located side by side, the waterfall fixing the site of the mill. Comparatively few such sources of energy could be utilized, however, since the greater number of our waterfalls are located in inaccessible mountainous regions to which the transportation of raw materials would prove difficult and expensive.

The development of the steam engine made it increasingly important that some agency be provided for the transmission of energy from the source to the consumer, since the steam engine could be operated most economically in those regions where fuel was abundant or easily transported from the mine When conditions prompted the use of steam-engine power at tide-water, coal in many instances could be transported in ships at low cost, but inland cities were only supplied at greater expense. The same agency that makes it possible for man to converse at great distances with his fellow-men can now be used to transmit energy from the mountain waterfall or from the coal mine to a distant city Manufacturing enterprises can thus be carried on in localities where labor and raw materials are most abundant, the required energy being supplied from a source located hundreds of miles away Favorable locations can be selected for both energy conversion and factory site, the two being connected by a transmission line by means of which electricity delivers energy from one site to the other In this respect the modern genie does his work somewhat grudgingly, however, for he has yet to be stirred to bridge the distances to which he carries the human voice. The extension of the distance to which energy may be transmitted economically from the present two hundred seventy-five odd miles to greater distances is one of the great problems which confronts the scientists of our century

With reference to the conversion of the chemical energy of coal into electrical energy, the electrical transmission of that energy has in addition made possible the centralization of our power plants, with a consequent decreased cost of the electric energy. The possibility of transmission of energy over great distances has then brought about the construction of enormous power plants containing converting machines of such great size that the resulting cost of energy per unit is rendered low and within the reach of the individual consumer The extensive use of electricity in the factory and the home is in a large measure due to the consolidation of our power plants, which in turn is made possible by the efficient transmission of electric energy to any point in the surrounding region.



HELL GATE STATION

With its turbine room next to the river, phase isolation of all electrical equipment, ashes sluiced by hydraulic means, large outdoor coal storage, use of boilers with superheaters six tubes above the combustion chamber, extensive equipment of motor-operated valves and latest work in coal-handling facilities, this station of the United Electric Light & Power Company, New York, is unusual.

In most modern industrial plants the familiar arrangement of shafting, belts and pulleys has given way before the more flexible electric drive. The large amount of energy formerly wasted in mechanical drive may now be utilized for driving machinery. Buildings may be erected at less cost; they may be grouped or extended without regard to the limitations impressed by shaft drive, and the individual machines may be located in positions such that the manufactured product requires a minimum of handling. The elimination of overhead belting leaves more head room for the operation of cranes and makes for better illumination. Ab-

Courtesy of Electric Controller & Manufacturing Co.
LOADING CAR COUPLINGS, STILL TOO HOT TO HANDLE, WITH AN ELECTRIC LIFTING MAGNET

sence of dripping oil from shaft-hangers and of dust agitation by belts brings about greater cleanliness in operation, with increased health to the employees and less damage to the finished product. Electric drive has proved more reliable than the shaft drive, and its flexibility is such that individual machines may be driven for overtime work without bringing the entire plant up to speed. Many operations which require accurate speed control are carried on more effectively Simplicity of speed adjustment and ample power reserve make for increased production at a decreased manufacturing cost. Accidents have been found less frequent in the electrically driven plant. This fact, together with the decreased noise, better illumination and cleaner surroundings, is of the greatest importance to the employer and employee, since labor finds greater contentment in the working conditions. The factory itself need no longer scatter smoke from its chimneys or dust from its ventilators over the surrounding region since electrical devices are available for reclaiming the unburned cinders and soot particles from chimneys or the valuable cement dust, for example, which might otherwise be lost. The electric ozonizer installed in flues over vats emitting foul odors removes the odors from the rising gases so that plants which must otherwise be located outside of the cities can be established in more convenient places without opposition. In plants where iron of various shapes must be transported, powerful electric lifting magnets inside or outside in rain or snow give increased capacity for handling materials.

One of the most important applications of electric power has been in connection with electric traction. At the present time there are essentially two systems of motive power employed on our railroads, the steam locomotive and the electric locomotive. The steam locomotive is necessarily wasteful and restricted in generating power because of its space limitation, while the electric locomotive may derive its power in ample quantities from a large efficient central station. A moving steam-power plant is, moreover, subject to a high rate of depreciation and requires a greater maintenance expense than the simpler electric locomotive The smoke nuisance associated with the steam locomotive is furthermore done away with in the electric locomotive, and this point, which is of the greatest importance where traction must take place underground or in large cities, has frequently been the sole reason for the substitution of electricity for steam. The universal use of electric traction for local city elevated, surface or underground lines is due to its smokeless properties, and to the possibility of attaching motors to each car so that the cars can be operated singly or in small trains.

THE LARGEST ELECTRIC LOCOMOTIVE IN THE WORLD

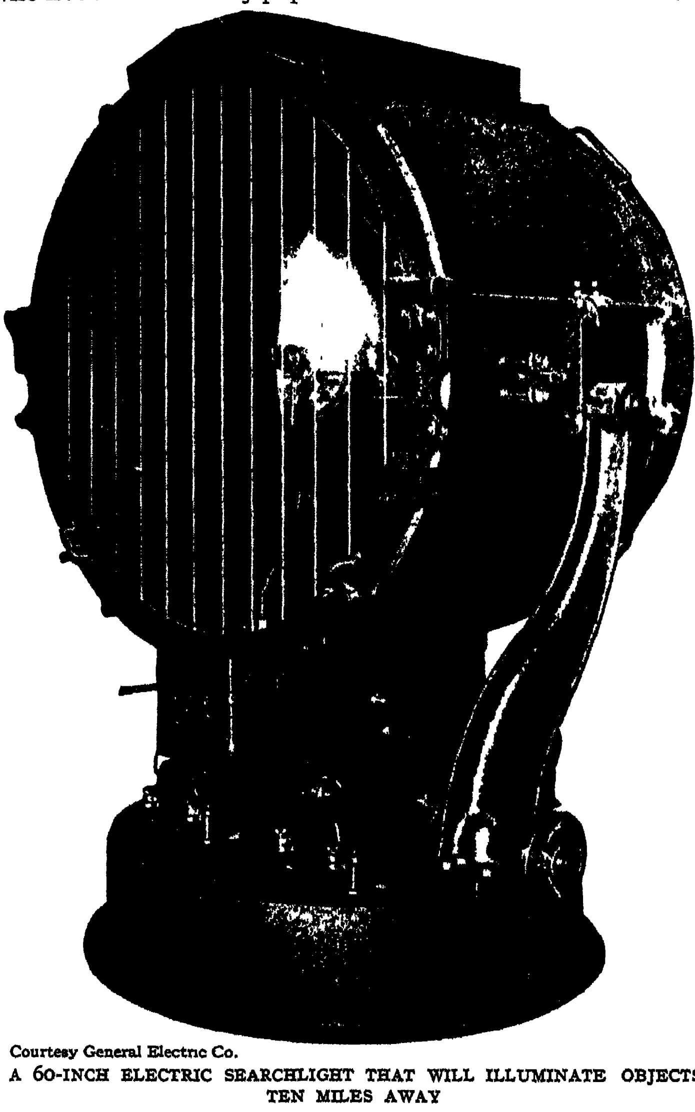
This 3000 horse-power, 282-ton locomotive is 112 feet long and hauls passengers and freight trains over the Rocky Mountains.

Photos courtesy General Electric Co.

AN ALL-STEEL HIGH-SPEED SUBWAY TRAIN

Each car weighs 43 tons and seats 72 passengers with standing room for as many more.

This use of electricity has been of incalculable benefit to modern housing conditions, since many city workers are able to reside in the more healthful outskirts of the cities without consuming great time in transit from the home to the shop or office. Those who live in the densely populated city districts, on the other hand, are provided with inexpensive transportation to the open country where recreation or rest from city turmoil is assured. Social intercourse, business transactions, sight-seeing — all would suffer without the smokeless, noiseless electric motor. Interurban rapid transit systems developed in the less densely populated regions furnish passenger and small freight service to the bordering farms. Means are thus provided for the convenient exchange of country produce for city merchandise. The transportation of passengers and commodities by electric traction, the electric telephone and telegraph shorten distances to the extent that the inhabitants of cities and towns alike are in close communication and may share the advantages of each.



Courtesy General Electric Co.

A 60-INCH ELECTRIC SEARCHLIGHT THAT WILL ILLUMINATE OBJECTS TEN MILES AWAY

One need only look down at night from a hilltop upon a large city spread out on the plain below to appreciate the effect of the electric lamp upon modern life. Gleaming lights are seen on every hand illuminating streets, office buildings, stores and homes. Moving lights on street cars and automobiles circulate back and forth and myriads of electric signs, bejeweled with changing colors, burst into view with ceaseless activity. All this has taken place since the time when Abraham Lincoln lay on the floor before a flaring fireplace working his sums. Electricity has made the present generation independent of the sun; business is no longer dependent on the length of the day, and the hidden terrors in the blackness of night are scattered beyond the pale of light. Great searchlights containing a light source rivaling that of the sun may project their bright beams over miles of land and sea. Command the modern genie to illuminate your book, light your highway, penetrate the walls of your houses even, and he will obey you. Push the electric switch and darkness is changed to light.

Courtesy The New York Edison Co

LOOKING UP BROADWAY FROM 44TH STREET

Flashing electric signs, scores of street lamps, brilliantly lighted theaters and restaurants, illuminated street cars and automobile headlights combine to turn night into day along the Great White Way

© Newman Traveltalks and Brown & Dawson, N. Y.

THE BAY OF BOTAFOGO, RIO DE JANEIRO, WITH THE PEAK OF CORCOVADO IN THE BACKGROUND

Rio, "the best lighted city in the world", is a fairy scene at night viewed from the encircling hills.

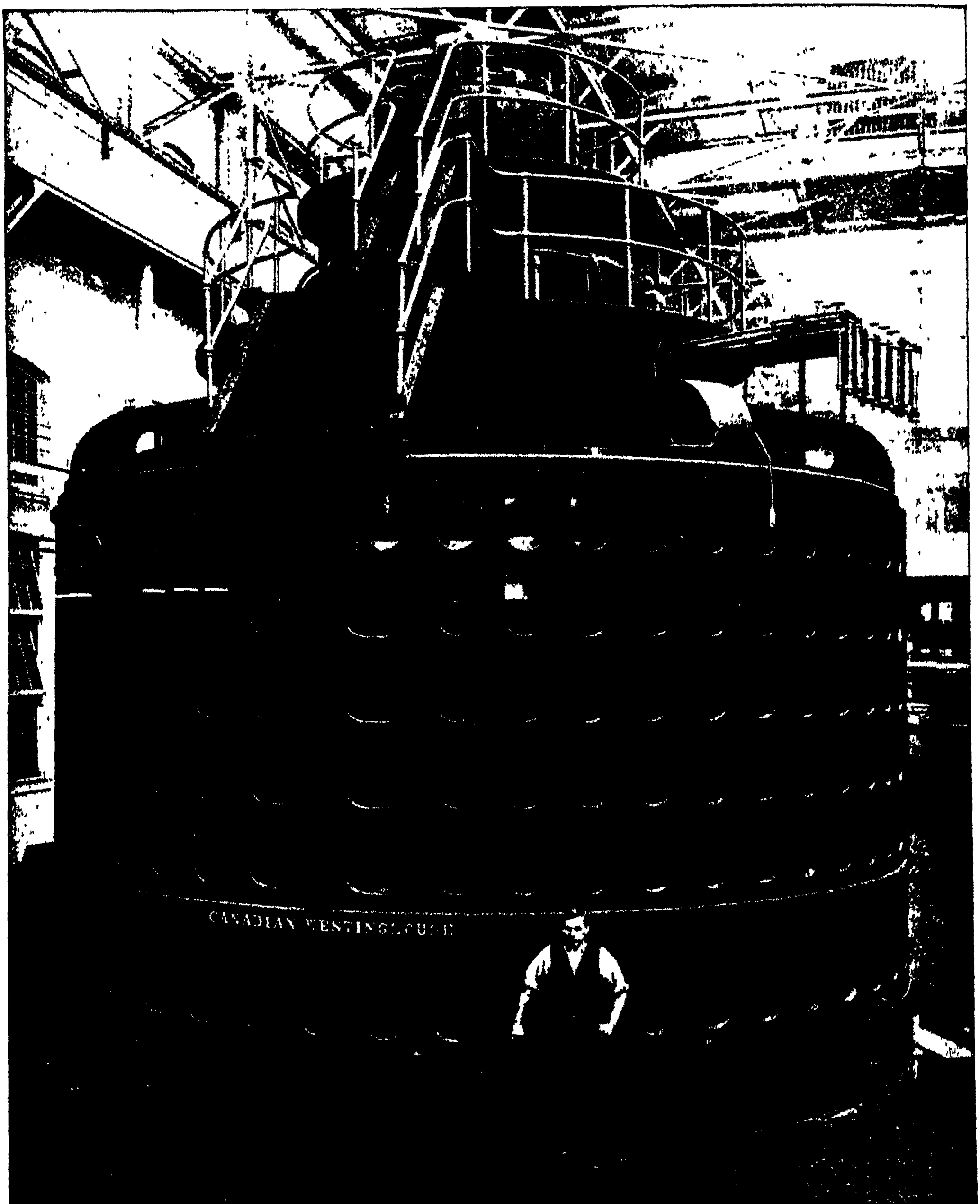


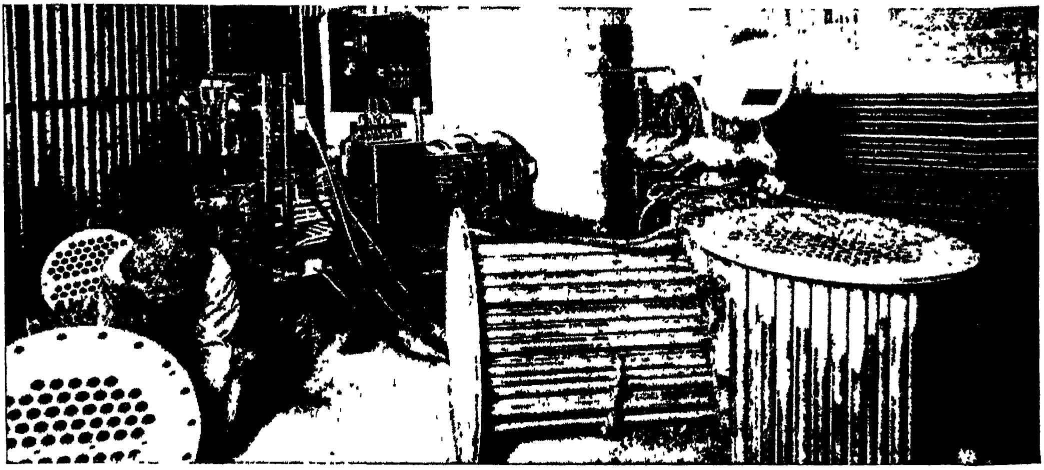
Photo Ewing Galloway, N. Y.

THE LARGEST TURBINE ELECTRIC GENERATOR IN THE WORLD

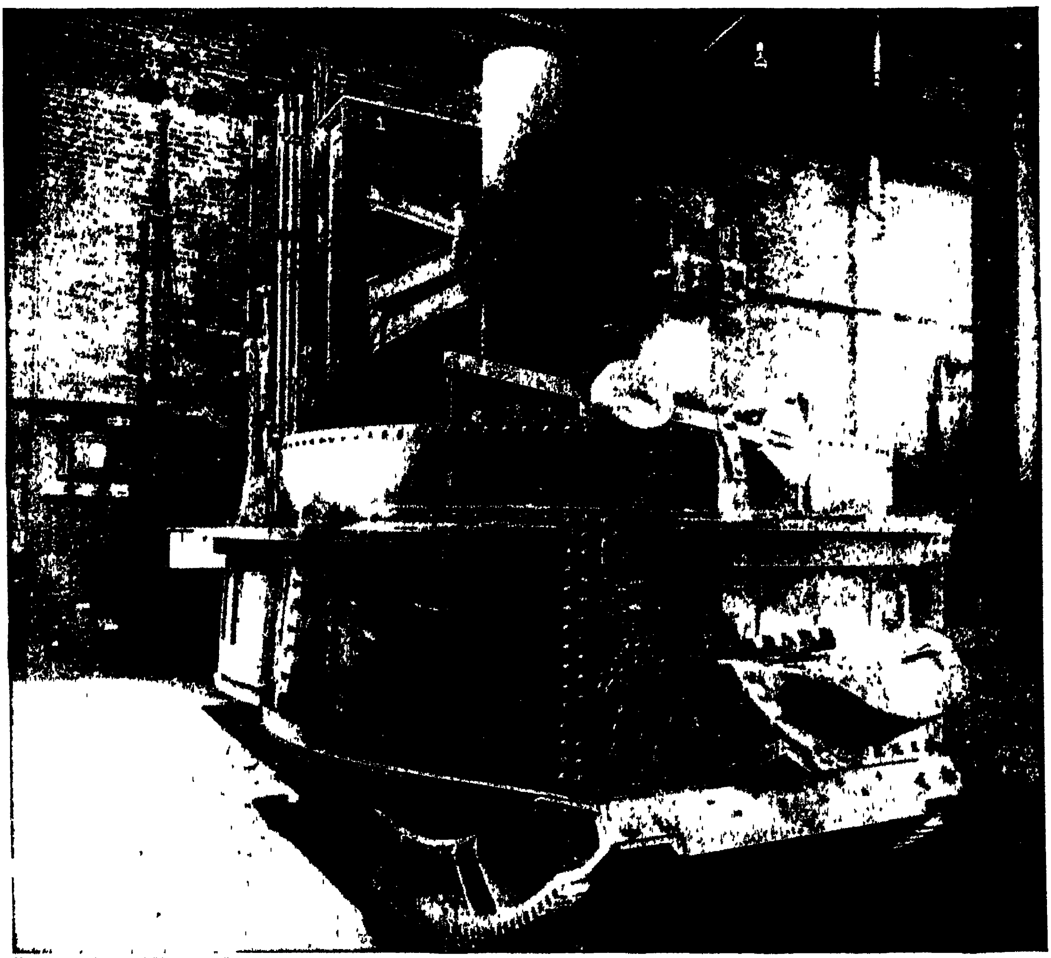
One of the 55,000 horse-power generators in the Queenston-Chippawa hydro-electric power plant. Turbines of this kind are supported on a cushion of water with such delicate accuracy that, unless braked, it takes twelve hours after the power is shut off for them to come to complete rest.

In addition to the service which electricity renders mankind in driving the machinery of our industrial plants, it may be made to extract the valuable constituents of our mineral deposits for utilization in the arts. The electric current may thus separate pure metal from other materials with which it is naturally associated, a task which in most cases could not be accomplished as efficiently or as cheaply by any other agency. These metals may then be plated in layers of any desired

UTILIZING THE HEAT OF THE ELECTRIC ARC



ELECTRIC ARC WELDING STEEL TUBES INTO TUBE SHEETS WITH A PORTABLE WELDING SET



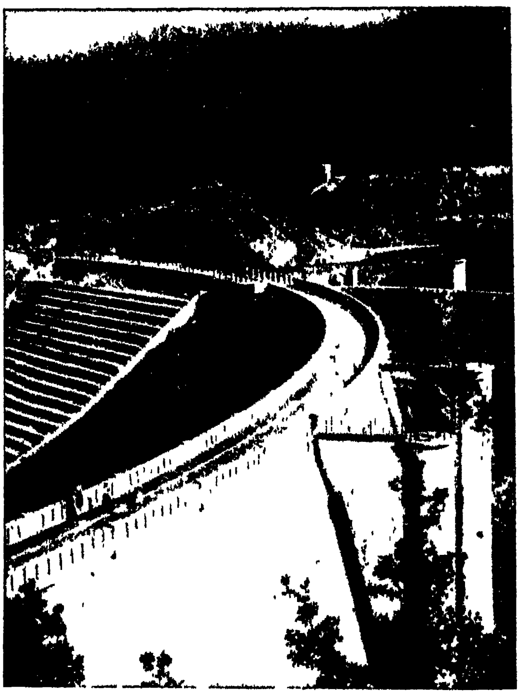
Courtesy General Electric Co

SIX-TON HERAULT ELECTRIC FURNACE

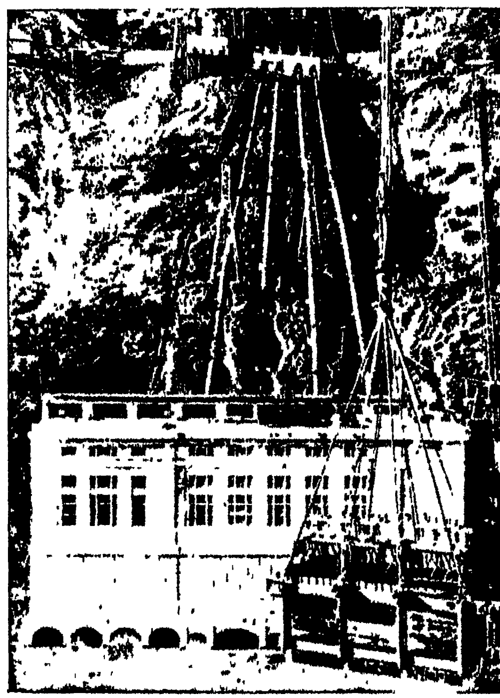
An electric arc playing between the two vertical carbons produces a temperature under which all solid materials become liquid.

thickness on cheaper materials by the same electric current. This plating property of electricity is utilized for producing the multitude of iron utensils protected against corrosion by a coating of tin or zinc. The tin can in which the fruits and vegetables of the summer season are preserved for winter consumption owes its existence to the electric current. Many materials which can only be manufactured or extracted from the adulterated sources at high temperatures would be unavailable without the electric furnace. In the high temperature of the electric arc, materials which are found infrequently in nature may be produced in large quantities for the use of mankind. Graphite, carbide and many other substances, even diamonds and rubies, may be artificially manufactured by the electric servant. Many kinds of electric welding machines are in use which swiftly attach one metal to another; wire fencing, for example, being woven as in a loom and each point of contact welded strongly together.

Swift as electricity appears in the forked lightning and in the ocean cable it may still be stored in batteries, which after being charged may be made to deliver power when needed in the automobile, the submarine or the airplane, for example. No longer does the miner grope his way through the black caverns aided by a flickering candle or lamp. A small storage battery slung across his back delivers energy to a powerful electric lamp which projects a brilliant beam of light from his cap to the path before him.



THE DAM IN THE EIFEL VALLEY BEFORE FLOODING
Note the step spillway, reinforcing the dam's resistance to the coming thrust of backed-up water.



A POWER-GENERATING PLANT IN CALIFORNIA
Conveying across the Feather River a 10,000-kilowatt, 100,000-volt transformer to a hydro-electric station.

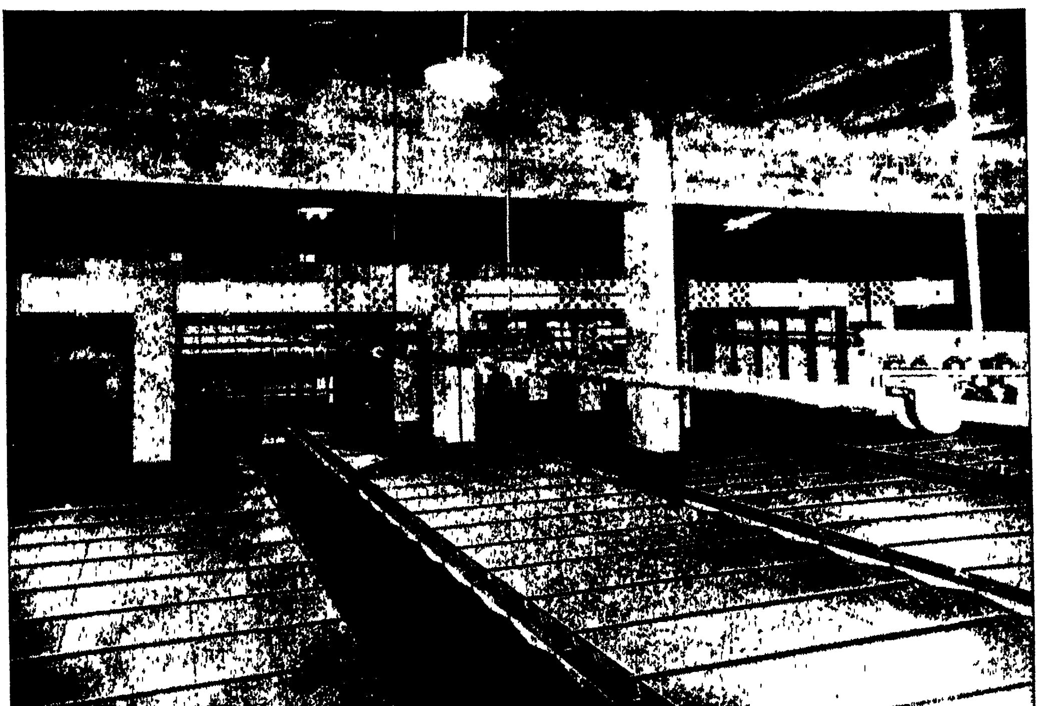
Electric power stations in the event of breakdown may continue to supply energy which has been stored in a huge battery. Electricity may be produced in small amounts by another kind of battery by chemical reaction without charging. Such primary batteries in a variety of sizes find extensive use in portable flashlights, for driving toy motors, for bell ringing and for house telephones.

While heavy electric currents passed through the human body produce fatal muscular reaction and are used in many

Courtesy Edison Storage Battery Co.

MINER EQUIPPED WITH EDISON NICKEL IRON ALKALINE STORAGE BATTERY AND ELECTRIC HEADLIGHT

Note the wide arc of illumination.

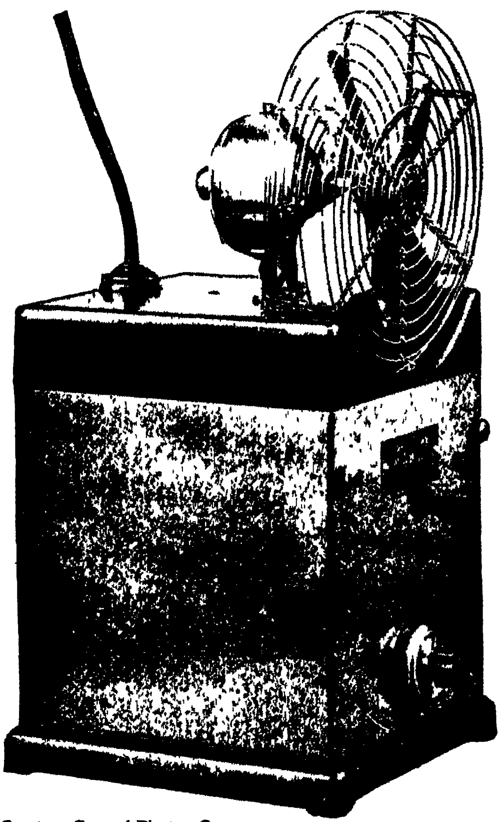


Courtesy Electric Storage Battery Co.

A LARGE CENTRAL STATION STORAGE BATTERY

Which stands ready to supply electricity for light and power should other sources fail.

states for the electrocution of criminals, weaker currents have been found to possess curative properties in connection with certain nervous diseases. In addition to the direct application of electric current to his patients, the modern physician makes extensive use of electricity in X-ray tubes for photographing internal deformities and fractures and in powerful electro-magnets which will extract particles of iron from the eyeball, or other parts of the body. Air passed through plates



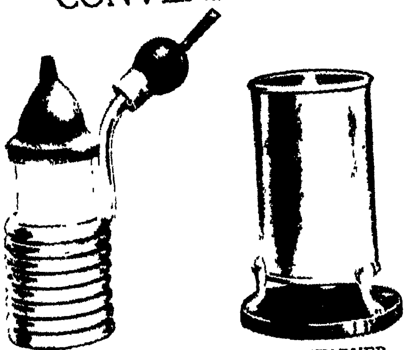
Courtesy General Electric Co
ELECTRIC FAN THAT CIRCULATES AIR CHARGED WITH OZONE

highly charged with electricity is charged with ozone which acts as a powerful deodorizer for the sick-room and as a stimulant to those who breathe it. Plant life subjected to a mild electrical discharge grows more vigorously and such electrical forcing, while not adapted to large areas, is used successfully in hothouses for hastening the growth and for increasing the quantity of flowers and vegetables.

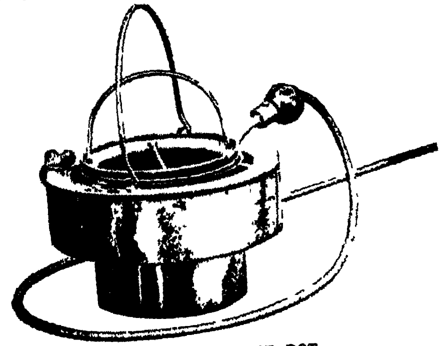
Many church organs are played electrically from a console, which is connected to the organ by a cable of wires with the advantage that the console is movable and may be located at will in any part of the building. Electrical musical instruments are being developed in which the vibrations of the electric current are converted into sound with unsurpassed possibilities for variation of quality as well as pitch. Sound of almost any musical instrument may be simulated accurately by a single instrument, or the sound of several musical instruments may be reproduced simultaneously, giving the effect of an orchestra. Electrical pianos have been constructed in which the wires are set in vibration by electro-magnets producing a more pleasing effect than by the usual method of striking the various wires with felted hammers.

It will be seen that man has harnessed electricity to do for him practically everything that he commands. Man has not yet contrived to make electricity bring to him a picture of a distant scene, although crude pictures have already been sent from one city to another by electrical means Present research along these lines may reveal the possibility of adding to the telephone instrument a device whereby those conversing will be able to see, as well as hear each other. The accomplishment of the transmission of sight, as well as of hearing, will weld the last link in the chain of long-distance communication. Electricity will then have transported the person with whom you wish to converse to your very side. An electrical device is available by means of which the business man may sit at his desk and write on a piece of paper some miles distant. He. may, for example, make his signature on a check in another office without traveling the intervening distance. If he calls up an acquaintance on the telephone and is informed of his absence, he may still speak his message through the telephone into an electrical device on the distant desk, and when the acquaintance returns he can then listen to the message word for word just as it was spoken.

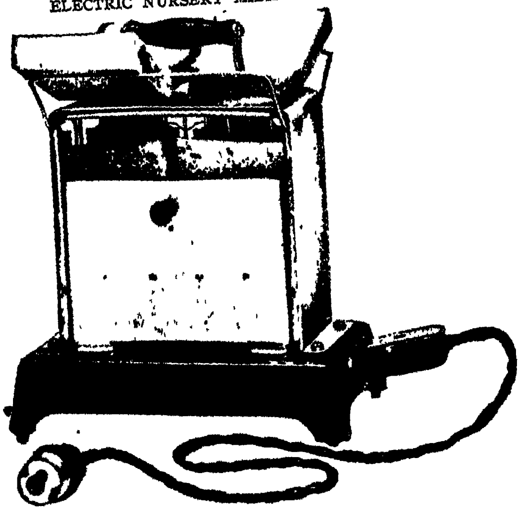
CONVENIENT ELECTRIC HEATING DEVICES



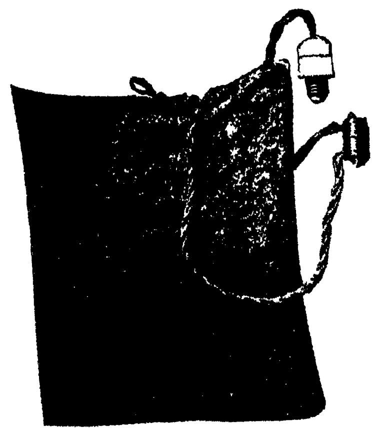
ELECTRIC NURSERY MILK WARMER



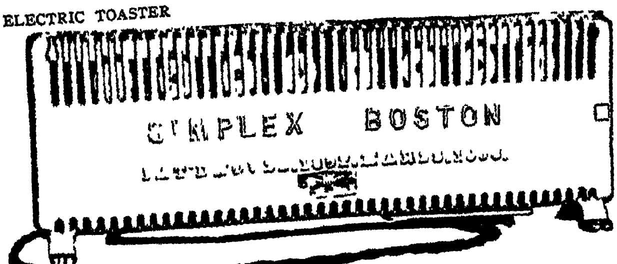
ELECTRIC GLUE POT



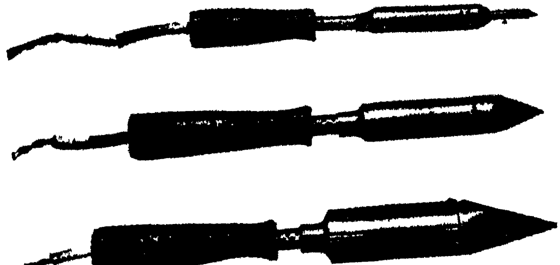
ELECTRIC TOASTER



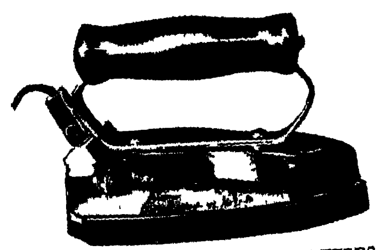
ELECTRIC HEATING PAD



ELECTRIC RADIATOR



ELECTRIC SOLDERING IRONS



ELECTRIC IRON, SHOWING HEATING WIRES

Courtesy Simplex Heater Co

USEFUL THINGS TO HAVE AROUND THE HOUSE

Consideration of the multitude of uses to which electricity may be applied would seem to indicate that the electric current possesses an unlimited number of properties The contrary is true, however, since all the detailed applications which we have noted are dependent in their execution upon a very few properties. An electric current, for example, causes any substance through which it flows to become heated. All heat or light applications depend upon this principle Furthermore, any substance carrying current and located in a magnetic field is acted upon by a force which tends to push the conductor through the magnetic field. All electric motors operate on this principle; the same is true of any electrical device in which motion is produced The third property, the chemical effect, is produced when an electric current is made to flow through certain chemical substances. The result is a changed structure of the substance, certain elements or compounds being liberated from the aggregate mass. There are then only three basic properties of electric current which manifest themselves so frequently in modern civilization. We have only to add the secondary effect of electric current on living organisms and its functions are made complete. The production of electric current is accomplished always by one of two methods. In each case the current is made to flow by a pressure or force called an electromotive force. An electric pressure or electromotive force is produced in any wire when a magnetic flux surrounding the wire is made to change constantly in a strength. This is the fundamental principle of operation of all dynamo-electric machines. The other method involves only the contact of two dissimilar substances and is the underlying principle of electric batteries

The varied and important uses which man has made of electricity are thus seen to be based upon a less complicated substance than is generally imagined. Turn on an electric lamp and the tungsten filament is heated to a light-emitting incandescence by the heat property. It is the same property that toasts our bread in the electric toaster, boils our eggs or roasts our meat in the electric oven. In the gasoline engine the gas is exploded by the hot spark produced electrically at the tips of the spark plug, and in the electric furnace the highest temperature produced artificially by man is created within a huge electric arc. Conversion of electric power to mechanical power is produced always by the reaction between electric current and magnetic flux. The same property that vibrates the hammer of our electric door-bells speeds the massive electric locomotive. The chemical effect is the same whether it be utilized for reclaiming metallic aluminum from its compounds or for galvanizing a coat of zinc on sheet iron. It is the very simplicity of electricity which has made it seem complicated, because its applications have been so clearly conceived and perfected that machines and devices containing thousands of parts have been constructed. If electricity had been more complicated in its properties man could not have applied it successfully to so many important uses.

A FREIGHTER ON THE GREAT LAKES PASSING DOWN THE DETROIT RIVER

These huge craft are designed expressl
quarters forward and the engine and bo

LABOR AND WEALTH

How the Progressive Economy of Labor is the Only Means of Increasing the Supply of Commodities

THE MACHINE AND THE MAN

WE now come to the deeply interesting considerations which attach to the economy of labor. In the first place, we shall do well to remind ourselves that the primary object of trade and industry *is not to make but to save work*. The conception that the making of work, or the giving of employment, is an end in itself is one of the most hoary of economic fallacies. We must remember, however, that if it is still cherished it is because the saving of labor in an imperfect civilization is accompanied by loss and suffering to individuals. We must not, therefore, be tempted to regard it lightly, and to dismiss with hilarity the employer or workman whose circumstances cause him to entertain the delusion.

The fallacy we refer to is often uttered by those who excuse the most luxurious and wasteful expenditure on the grounds that it "makes work". No matter how wanton an extravagance, there are never wanting those ready to make excuses for it on the ground that it gives employment. If the making of work is the end of life, then it is obvious that, the more laborious trade and industry can be made, the better they are for mankind. Why plow, when it would obviously make more work to loosen the soil of a field by digging with a stick, or even by pulling its clods to pieces with the fingers? Why use a cart, not to mention a railway, when it is obvious that more work would be made by dragging loads over a road by manual labor? Why, indeed, make a road, when it is obvious that, if it did not exist, there would be much more work made in moving things about?

When a workman says that he is suffering from lack of work, what he really means is that he is suffering from lack of income, and work presents itself to him as the only means of obtaining the income. We must not wonder, therefore, if the necessity of finding work presents itself to him as the main object of life, and if he is but only too prone to entertain the economic fallacy to which we have referred. Indeed, it is not much use to the unemployed workman to remind him that one of the prime objects of civilization is to reduce the amount of work to be done to produce a given amount of comfort, or a given quantity of utilities.

The workman is only an insignificant part of an economic chain which he did not create and cannot control, and he is forced only to consider the immediate point, which is how to get a wage. We must not expect him to question the economic bearings of the means by which he earns his wage. The workman may be an exceptionally intelligent man, able to tell you that what most wants doing in his immediate neighborhood is, let us say, to rehouse people like himself in order to enable them to live decent lives. He may know that economic truth, but of what avail is the knowledge to him? He must find income by obtaining employment; and if, therefore, the work offered him is to assist to build up a luxury, and, in effect, to waste his work from a social point of view, he must needs accept the offer of employment, and he must needs regard the making of work — however foolish, however wasteful, and however absurd — as the immediately desirable thing.

The fallacy of thinking that work is what mankind wants

In spite of the castigation of economists, the fallacy of making work, therefore, remains current, and is only too likely to do so for a long time. Senior, who wrote in the first half of the nineteenth century, very effectively dealt with the subject when he said: "Those who maintain that unproductive consumption does good by affording employment must forget that it is not employment, but food, clothing, shelter and fuel — in short, the materials of subsistence and comfort — that the laboring classes require. The word 'employment' is merely a concise form of designating toil, trouble, exposure and fatigue. It is indeed sometimes elliptically used as implying the subsistence which is purchased by enduring it. A poor man complains that he wants work. He might work to his heart's content, and with no man's leave, if he chose to carry stones from the bottom to the top of a hill. But what he wants is work as a means of obtaining payment. He would be happy to get the payment without the work.

"Toil, exposure and fatigue, *per se*, are evils, and the less of them that is required for obtaining a given amount of subsistence and comfort, or, in other words, the greater the facility of obtaining that given amount, the better, other things being equal, will be the condition of the laboring classes; indeed, of all classes in the community."

Ruskin, writing as long ago as 1879, exposing the fallacy of "making work", as uttered by the then Bishop of Manchester, said: "I cannot easily express the astonishment with which I find a man of your lordship's intelligence taking up the common phrase of 'giving employment', as if, indeed, labor were the best gift which the rich could bestow on the poor. Of course, every idle vagabond, be he rich or poor, 'gives employment' to some otherwise enough burdened wretch to provide his dinner and clothes for him; and every vicious vagabond, in the destructive power of his vice, gives sorrowful occupation to the energies of resisting and renovating virtue. The idle child who litters its nursery and tears its frock gives employment to the housemaid and seamstress; the idle woman who litters her drawing-room with trinkets, and is ashamed to be seen twice in the same dress, is, in your lordship's view, the enlightened supporter of the arts and manufactures of her country."

The saving of labor the real road to the increase of wealth

The royal road to wealth is by the saving of labor. The people of the world become grouped and even crowded in those parts of the world in which a definite amount of work can be done with the least amount of labor. That is why, before the days of power-development, fertility was the chief magnet for population, and that is why, again, at a later date, as we saw in former chapters, the discovery of the use of coal drew men to places where cheap fuel helped them to work most easily.

The division of labor has largely and increasingly helped man to economize effort. The distribution of men, of tribes, and even of nations, amongst different occupations naturally arose from the discovery of this great economic truth. We even find the division of labor among the higher orders of insects, and among men it has existed, in some form, in all recorded history. By following a particular line of effort, one man became an expert carpenter, while another became an expert blacksmith, and each was able to do better work because he stuck to his particular calling. Thus men learned to work for each other, and, by doing so, to save work, and to get more from their efforts than if they each attempted to follow all trades, and each attempted to do everything for himself. Trade, of course, thus had its origin, the division of labor making it necessary to exchange the products of one calling for the products of others.

The grouping of industries in districts as a means of economizing labor

Both in ancient and in modern times the division of labor has found expression in the devotion of entire districts to a particular form of industry, the products of which are sent out of the district in exchange for the subsistence of the district.

The United States affords many excellent examples of the localization of industries, which is really another name for the geographical division of labor. Thus the boot and shoe industry is predominant in Massachusetts; collars and cuffs are made in Troy, New York; gloves are produced in Gloversville and Johnstown, New York; brassware in Waterbury, Connecticut; carpets, in Philadelphia; jewelry, in Providence, Rhode Island, and the neighboring towns of Attleboro and North Attleboro, Massachusetts; plated silverware is made in Meriden, Connecticut; silk, in Paterson, New Jersey. Other examples might be given, and, of course, the generally recognized division of the country into industrial and agricultural sections, characterized by different types of industries, and by the dominance of different crops is itself an example of the territorial division of labor.

Different causes that explain the localization of industries

Different causes explain the localization of different industries. The proximity of raw material or of fuel may be the determining factor. Or it may be the accessibility of markets or the presence of waterpower. The availability of a trained labor supply counts for much, and so does what has been called the "momentum of an early start". These last two causes explain the persistence of a particular industry in a certain locality generation after generation. Frequently, however, no one of these factors, and no combination of these factors, seems adequate to explain the presence or the development of a certain industry in a certain place. Here we have to fall back upon the human factor, — the variable in so many economic laws. Physical and economic facts will sometimes suffice to explain just why some industries should be distributed as they are, but, in other instances, the only possible explanation is that men of energy have set themselves at work to build up a great industry in a particular locality, and have succeeded.

The principle of the division of labor is thus very widely practised; and what it amounts to is that a certain amount of labor is saved by the division.

Adam Smith used a very effective illustration of the economy effected by the division of labor. He pointed out that if a blacksmith had to make nails without being used to the job, he would only make 200 or 300 nails a day, and not very good ones into the bargain. With practice, he might learn to make 800 or 1000 nails in a day. But bring up a boy to the nail-making trade, and he could turn out 2300 nails of the same kind in the same time. If Adam Smith lived now, he could take his illustration further and point out that, with the aid of suitable machinery, a man, or indeed a boy, can now make tens of thousands of nails in eight hours, by devoting himself exclusively during the day to the same machine. And it is not only dexterity that is gained by a man who devotes himself to one calling only. A great deal of time is saved, because the pursuit of a particular task saves the time which is lost in changing from one job to another.

The effects of the coming of machinery in subdividing callings

Preparing to do work necessarily takes time — the assembling of tools, materials, etc. — and if, therefore, a man did many kinds of work during a day, he would have to waste a lot of his day in preparing for each particular job and clearing up after it.

With the coming of machinery, the division of labor took a new form, and one very far-reaching in its effects. It served to *subdivide callings*, and in many cases to destroy old and honorable employments. The devotion of a man's life to the trade of shoemaking is an example of the division of labor. The breaking up of shoemaking into minute subdivisions, each of which is followed by a particular set of men or women, destroys shoemaking in the old sense altogether, and substitutes a highly complicated, organized industry, *the workers in which do not know how to make shoes at all.* It is a strange thought that there are thousands of men and women making shoes in the United States today who would be at a loss to know what to do if they had to make a pair of shoes from start to finish. They only know their infinitesimal bit which contributes to make the completed whole.

The apparently high cost of machines that make cheap things

Sometimes the size or weight of a machine or press devoted to the production of some very small part of a commodity by the modern system of machine production seems almost ludicrous. A press costing many thousands of dollars may be solely devoted to stamping out bits of metal. The capital so devoted saves an enormous amount of labor, and enables cheap production to be attained. The costly machine at each stroke saves a quite considerable amount of work. Other costly machines do the same service for other small parts of the ultimate commodity. The final outcome is that a complicated article, such as a shoe, is produced as the addition of a large number of very small fractions of labor, with consequent great cheapness.

No better illustration of the process can be given than its application to the making of watches and clocks. When, in the early days of the watchmaker's art, a workman of great skill and ingenuity produced an entire watch, the result was a very costly and sometimes a very beautiful and ingenious article, which cost so much in labor that it could only be enjoyed by a few. A king, a nobleman or a rich merchant might possess such an object with some difficulty, for the wonder of the world at large. Later, when there was some amount of division of labor introduced, as in the justly celebrated Swiss watch industry, a watch came into existence which could be afforded even by the middle class. Nowadays watches can be produced at so low a cost that they can be sold for a dollar or two and can be owned by any one. These quite efficient articles are produced by stamping out the various parts by separate machines, and putting those easily made parts together. The result is a standard article, each of the parts of which is interchangeable with each of the smaller parts of any other of the hundreds of thousands of watches of the same kind produced.

In the last few years the same principle has been applied in America to the making of what was only lately a great luxury, the automobile.

The cheapening of the automobile by standardization and use of machines

If you apply division of labor as understood by Adam Smith to the making of an automobile, you get a very costly article indeed. We have applied to the automobile the same principle of standardization which is found in the shoe industry; and hundreds of thousands of cars of the same pattern are turned out, each of the separate parts of which has been produced under the system of extreme division of labor As a consequence, we find excellent cars offered at what seems an extraordinarily low price, but which is not extraordinary in view of the economical method of production.

The standardization of products has introduced great economies, not only in the machine industries, but in other fields as well. The whole tendency of the routine, mechanical methods of the modern factory system is to turn out products of definite kinds and of definite grades. Great economies are thus effected at the loss sometimes of the opportunity for personal expression on the part of the workman, and for the full and accurate satisfaction of the personal tastes of the consumer. The machine process is standardizing consumption as well as production. Economy and abundance are purchased at the expense of individuality and variety. To anyone who has viewed the problem without prejudice the conclusion must be that there has been a large net gain. Never before in the world's history have so many people been supported at so high a general level of comfort as in those modern countries which have best mastered and utilized the principles of the division of labor and of the factory system.

Throughout the practice of the division of labor it is apparent that there runs the principle of increasing wealth by saving labor; and this is as true of the old and simpler form of the process, which saw craftsmen engaged in carrying out in its entirety the manufacture of an article, as it is of the later form, in which one kind of manufacture is split up into many tiny individual operations.

The recentness of the machine age, and its great influence on human society

The inventor thus presents himself as a saver of labor, and since the beginning of the second half of the eighteenth century he has worked marvels in this direction. The machines were first supplied with great advantage to the textile industries. It was in 1764 that Hargreaves introduced the spinning-jenny. By and by there came the power-loom, and more than a hundred years have now elapsed since the hand-weavers' trade passed away. In 1769, Watt took out his steam-engine patent, and by 1781 he had made steam-working effective. As we have already seen, the steam-engine was really called into existence by the necessity to pump coal mines. In 1807, steam was first used in navigation, and it was in 1825 that the Stockton-Darlington railway was opened. In 1838, Brunel's "Great Western" crossed the Atlantic; and in 1831 Faraday discovered magneto-electric induction, the first discovery of the electric current or of galvanism having been made by Galvano on the threshold of the nineteenth century. We name these dates to remind the reader how short a period separates us from the realization by man of the powers which he now commands It is a span of time which counts for nothing in known history, but yet it is a period long enough to count for the passing of five or six generations, and to produce in the character both of individuals and of society a very considerable effect.

The complexity of the machinery of life under modern divisions of labor

Closely allied in nature to the introduction of machinery into a business is the organization of industries as a whole. Just as we save labor by applying machinery to enable one man to do as much work as many men could do without the machine, so we save labor by uniting the small, scattered units of a business, bringing them under one control, and eliminating all duplications of effort. This process, with which we shall have occasion later to deal at greater length, has gone far in connection with not a few industries.

As we have already noted, trade took its origin in the division of labor. As soon as men ceased to do everything for themselves, and divided up occupations between different families or groups, it became necessary to make exchanges in order to secure a varied subsistence. We see a modern community so divided and subdivided that it is true to say that not only does one half not know how the other half lives, but that few indeed of the individuals concerned pause to consider the working of the community as a whole, or the relation of their own share of work to the aggregate of the community's work. The average man does not stop to consider the extraordinary complexity of the organization which feeds him and clothes him and supplies him with comforts in exchange for some contribution, large or small, made towards the general fund of wealth.

Workman and manufacturer alike have little grasp on scheme of things entire

It is true not only of the average workman, but even of the great manufacturer or merchant, that, however intimate he may be with the particular groove in which he himself carries on his operations, he has little grasp of the scheme of things entire. In the old days it was easier to grasp the machinery of life. Foreign trade was very small in dimensions; and for the individual it was easy enough to understand the exchanges that took place in the small market town surrounded by an agricultural belt. The farmers took their produce to market, and found in the city the simple arts which mainly made up the economic balance. Today the population is congregated chiefly in large cities; and in these the complexity of economic forces hides the real nature and effect of transactions, and leaves the "man in the street" largely ignorant of the world. The stores in the towns sell articles which more often than not are made in places remote, and the modern merchant does not always know the real nature of the articles which he sells.

The area of the division of labor has, of course, widened with invention. The railway and the steamship have done more for trade than any other third cause, and at

each stage of their expansion they have widened the area of exchange. In the old days the butcher's shop was a place in which was retailed the meat of animals raised in the vicinity. Transportation next made it possible for people to eat meat grown at a considerable distance, and, combined with cold storage, has now actually made it possible for the Old World to eat the flesh of animals raised in the New World. No more striking instance than this could be given of the fruits of the division of labor.

It has been pointed out by Professor J. R. Commons that in the modern packing house the steer has been "surveyed and laid off like a map". The workers have been classified in over thirty specialized gangs, each man doing but one thing in the division of the carcass and hide. "Skill has become specialized to fit the anatomy" and the varied products sent to the ends of the earth.

International division of labor, and the exchanges to which it leads

This brings us to the *international division of labor*, which is only another branch of that geographical division of labor at which we have already glanced. Within our own country we find one district doing one kind of work, and another district devoted to an entirely different occupation. It is not surprising, therefore, that as between one country and another we find a considerable variation of products. This partly arises from variation of natural gifts. A country rich in power is naturally a manufacturing country. A country rich in fertility is naturally an agricultural country.

Just as a nation gains by the different parts of it being devoted to different occupations, exchanging with each other the products of their labor, so a country gains when its people, producing with facility and abundance certain commodities for which it is particularly suited, exchange those commodities for the products of other lands which have different advantages. In former chapters we have seen that if these exchanges had not been brought about it would have been impossible for the modern world to maintain so great a population.

International division of labor based on differences in natural resources

It is important to observe that international exchanges rest upon three very different bases, and that two of these are permanent and the other not necessarily so. The first permanent basis is the wide differences which exist in the natural resources of different parts of the world. England has plenty of coal and no sulphur, Italy has plenty of sulphur and no coal.

These are unalterable facts, and as long as coal is useful, Italy will have to get coal, if she needs it, by exporting something which she possesses — say, sulphur or olive oil — in exchange for it. Similarly, England possesses no sulphur, and must get what she needs of it by exchanges with Italy or some other country which produces it. Again the fact is unalterable. A very large part of the trade of the world rests upon such unalterable facts. The climate does not allow England to produce mahogany, or teak, or rubber, or gutta percha, or ivory, or mangoes, or cotton, or hemp, or jute, or cocoa, or coffee, or tea, or oranges, or lemons, or wines, or a host of other things that might be named. With regard to these, she will always have to rely upon supplies won by commerce; and so also it is with the many minerals and metals which her soil either does not produce at all or produces insufficiently for her needs.

It is conceivable that the United States, with its greater area, its larger variety of climates and soils and natural resources, might be able, with relatively less disadvantage, to produce all that it consumed. But in such case it would have to get along without many tropical products (or produce them for itself at extravagant cost) and it would find itself handicapped by the absence of certain important minerals and certain fertilizers. Most of all, it would find that it was producing for itself, with wastefully high expenditure of capital and labor, many commodities which it could have got more easily and more cheaply by exchanging its own best products — the goods it can produce to best advantage — for goods made by other nations. It is especially important to emphasize the fact

that, even if *absolutely* the United States had an advantage over every other country in the world in the production of every conceivable commodity, it would, nevertheless, be profitable for it to let other countries produce those commodities in which the advantages of the United States were *comparatively* least. By devoting itself to the production of the commodities in which its comparative advantages were greatest, the United States would be able through international exchange to get the maximum total wealth product, the maximum national income with a minimum expenditure of capital and labor, and with the smallest drain upon its natural resources. *Comparative advantage*, not absolute advantage, governs international trade.

The second permanent basis of international trade is found in differences of race genius as between the peoples of different countries. We find the people, or part of the people, of a particular country possessing some gift which enables them to excel in a particular branch of work, or to add to it something which gives it individual character and value. Here, again, we are confronted with what may be termed an unalterable basis for trade.

The third basis of trade is acquired skill; and here we have something which, as time has already shown, is a very uncertain basis for the exchange of commodities. Sometimes, by obtaining a start in a particular industry, as England did through the inventions of Hargreaves, Crompton, Arkwright and others, the people of a country seem to acquire a particular talent for handling it. For reasons which are sometimes obvious, sometimes obscure, special skill in particular industries is acquired by the people of certain countries, and when once an industry has obtained a special organization and concentration in a country, it acquires strength by virtue of the fact, coming to possess facilities for obtaining material, labor, etc, which enable its members to work with advantage. There is no absolute permanency in such organizations, however; and it does not follow that, because a certain city or country possesses at this time a strong trade position, it will forever continue to hold it.

It is clear that so far as trade rests upon the third basis we have named — that of acquired skill — there is no permanent basis for trade; and city A in country B, which at present does a fine export trade in a particular article with, say, Australia, may find Australia herself come to possess equal or even more skill in the production of that identical article.

Other things being equal, the division of labor must lead to industries being carried on in those parts of the world best suited to them — *i e*, near power, or near materials We cannot wonder that a wool-producing country like Australia or New Zealand should aspire to manufacture its own woolen goods instead of exporting its fleeces to be worked upon at the other side of the world and returned to it in manufactured form. We cannot wonder that wood-pulp should be largely made in places where the timber out of which it is made is grown. Only lack of power can ultimately prevent the material being worked up in the place where it is produced, and when the world's water-power is developed, or if new sources of power are discovered, we may see very great changes take place as the result of the further great division of labor.

It is only the setting free of labor by economizing it that enables new tasks to be undertaken. If the raising of food was so laborious as to occupy nearly all the time of the human race, then men and women would be able to command little else but food. As soon as food-raising becomes simpler, a certain number of workers are set free to make homes and to make clothes As soon, again, as these tasks are lightened, a certain number of people become free to supply further comforts.

Summing up what we have considered in this and the preceding chapter, we see that labor is saved and set free by continuous processes which may be briefly expressed as follows:

1. The storing of the products of labor as capital or stock;
2. The division of labor;
3. The invention of new machinery and processes,
4. The exchange of commodities, which has its roots in the division of labor.

It is important to observe that what we have termed the setting free of labor by the saving of labor need not cause unemployment or distress to any man, but may easily do so through lack of proper social and industrial organization.

Let us suppose that in a given community of a million people there are ten different occupations, and let us distinguish these by the letters A to J. Let us suppose, further, that the members of this community, working economically by known methods, are divided up in the following proportions between the ten industries

Industry	Number of Workers
A	100,000
B	50,000
C	125,000
D	200,000
E	75,000
F	50,000
G	50,000
H	300,000
I	25,000
J	25,000
All ten industries	1,000,000

Now let us suppose the community of a million persons to increase to five million, and let us suppose, further, that while the population so increased no labor was saved in any of the ten occupations and that, therefore, each of the ten industries had to employ the same *proportion* of the community as when the community numbered only a million. Then, when the community reached five million, the division of occupations would be as follows:

Industry	Number of Workers
A	500,000
B	250,000
C	625,000
D	1,000,000
E	375,000
F	250,000
G	250,000
H	1,500,000
I	125,000
J	125,000
All ten industries	5,000,000

What does this mean? It means that, although the community has multiplied five times, it cannot be a penny better off per individual, because no labor has been saved, and exactly the same proportion of workers is needed for each trade. Not a single new trade can come into existence, because a new trade under the circumstances can only be gained by giving up an old one or part of an old one. No matter how sorely other industries, which we will call K, L and M, may be needed, they cannot be started, because there is not a single worker free to engage in them.

It must be admitted that the example that we have just given is fanciful and even impossible. With the growth in the size of industries, there come changes in their organization, increased applications of the principle of the division of labor and further economies. We are not referring here to the increase in the size of the individual plant. This may be economical and advantageous up to a certain point. But the reader will have noticed that the largest industrial establishments he knows are, after all, of limited and fairly definite size. Further growth is accomplished by duplication, by building more plants, rather than by extending old ones. The advantageous size of plants varies, of course, with different industries.

Nor are we discussing agriculture, where, as we have seen, a large increase in product can generally not be secured except at a considerable increase in the cost of production per unit. In agriculture, the "law of diminishing returns" is at work. Larger crops cannot be had without resort either to poorer soils than those already in use, or without the more thorough and intensive cultivation of lands already cultivated. Either alternative means more cost per unit of product.

We are discussing, then, neither agriculture nor the *single* industrial establishment. We are focusing our attention upon manufacturing industries as wholes. Now, within any industry an increase in the demand for its product will almost invariably lead to important economies. For example, even if the only result is to multiply the number of plants, there will be some

gain, for it may be assumed that there will result a better distribution of plants so that the costs of transportation for the average unit of product will be decreased In general, however, a growth in the output of an industry as a whole will result not only in an increase in the number of plants, but also in a further *differentiation and specialization* as among the different establishments. When the shoe industry of the United States reached a certain size, it became possible to build large factories specializing in certain grades of shoes, in men's shoes, or women's shoes, or children's shoes It became profitable to build separate establishments for the making of lasts, and for the making of shoe machinery With the development of the American iron and steel industry, we have had not merely the multiplication of blast furnaces and rolling mills, but we have had the further development of tube mills, rod and wire mills and mills turning out other finished products of different types The growth of the automobile industry has been accompanied by the development of specialized industries making motors, bodies, clutches, axles, and other parts.

In short, with the growth of an industry, division of labor as among the different plants in the industry becomes not only possible but profitable, and, because profitable, inevitable. The division of labor and the roundabout methods involved in the machine process, — "the making of machines to make machines to make machines", — are feasible only when there is a market for a fairly large output. With an increase in the market, the possible and practicable economies of the division of labor increase and multiply. No one factory can afford to equip itself with a large outfit of special machines and tools unless it is assured of large sales for its products. With only a small market, the slower and most wasteful methods of direct production, involving less "roundaboutness", less division of labor, must persist.

But these considerations, important as they are, do not lessen the significance of the fundamental truth that a new industry can be started in a country only by freeing labor from an old industry.

Every inventor, therefore, who displaces labor is a servant of mankind. Every business organizer who shows how one man can do the work which two men used to do increases the wealth of the world.

But while all this is true, it is also true that for a specific individual a new invention may spell disaster and ruin. If to-morrow an inventor were to produce a house-painting machine which would apply paint to wood-trim, walls and floors as well as it can be done by hand, but with only one-twentieth the amount of labor, then a very large number of house-painters would be thrown out of work, and they would suffer severely. The cheapening of house-painting would lead to more such painting being done, and this fact would reabsorb some of the displaced labor. The community as a whole would benefit considerably; and children growing up into new workers, not being required so much for the house-painters' trade, would be able to engage in new occupations. But a certain number of aged or aging house-painters would permanently suffer, and in some cases might even be reduced to want.

The loss to the individual by changes beneficial to the community

We see, therefore, that while it is quite necessary for the progress of society, and for the increase of the wealth and comfort of the community, for labor to be continuously and progressively displaced and set free to engage in new occupations, what is on the whole and in the long run a beneficent process is attended for a minority of individuals by quite undeserved loss and, possibly, acute suffering.

If the community as a whole thoroughly understood the importance of the matters of which we have been speaking, it is surely clear (1) that they could not stand in the way of new inventions, and (2) that they would see to it that there should be no individual loss through the application of new inventions. It is not impossible, it is not even difficult, to make social and industrial arrangements by virtue of which men who are thrown out of their trade by the march of invention may be tided over until they can find a new employment.

When our organization has reached a higher degree of development, the essential truth, that the object of trade and of industry is not to make work but to create a plentifulness of utilities with the least possible amount of work, will be realized, and, when it is realized, few difficulties will stand in the way of its accomplishment. To this we must add, however, that the provision of work which shall in itself be pleasurable, which will afford an avenue of self-expression for the workman, which will unleash his energies, enlist his interests, and enrich his life, is, in itself, an object of social policy comparable in importance with the provision of a plentiful supply of utilities. We may increase utility by the simple, even if difficult, device of making work itself less of a disutility.

Nothing can ever make the attendance upon machinery a task fit to be prolonged in all cases for many hours at a time. How, then, is civilization to cure itself of the evils which can so easily arise from the use of machinery? How is it to retain the advantage of cheap production while obtaining for the individual a proper recreation of faculties? The answer appears to be that, when work comes to be thoroughly organized, what machine-work will be necessary will be so devised and so distributed that no member of the community will be reduced to the rank of a machine tender for any considerable length of time. We cannot abolish the machine; it would be foolish to abolish the machine. Civilization must, however, abolish the machine slave. Attendance upon machines would be a different matter if it were so reduced to a thorough economy, and so shared as a social duty, that no man or woman had to do more than man or woman can bear without losing his or her well-being.

The most practicable method, however, of lessening the evils of the machine system is to bring about a more thorough utilization of that system The routine work of machine tending, where it is work of a kind that does not enlist the interests and imagination of the workers, is itself precisely the kind of work which may itself be reduced to a machine process. The engineer, the foreman, the man in responsible charge of a complicated machine, finds in his work a plentiful opportunity to develop his own interests and powers The kind of machine tending that, from a social point of view, must become unendurable is the kind in which the worker becomes frequently a *part* of the machine, repeating a simple and monotonous physical movement minute after minute, hour after hour, and day after day. It is just these small routine movements which, with the perfection of the machine process, may be delivered over more and more completely to machinery. One way, perhaps the most important way, out of the admitted evils of the machine system is through the more thorough utilization of the possibilities of that system.

Photo Paul Thompson, N Y

WORKMEN'S COTTAGES BEING ERECTED IN HAMPSTEAD, LONDON, UNDER THE COÖPERATIVE SYSTEM

EVOLUTION OF THE TYPEWRITER

Development of the Machine That Does the Work of Hundreds of Pens

SPEEDING UP BUSINESS CORRESPONDENCE

SO accustomed are we to the many ingenious devices of this prolific age of invention that it is doubtful if even yet we fully appreciate the convenience of the typewriter. It is only by pausing a moment to compare the easy, rapid and legible work of the modern typist with the slow, laborious efforts of the ancient scribe that an adequate conception can be gained of the wonderful progress that has been made in the methods of recording thought and of facilitating the interchange of ideas. When the first practical typewriter was produced, no one realized how completely it would revolutionize the world's business methods. No one dreamed — not even its inventors — that it would expand the operations of business as the locomotive and steamboat had extended those of transportation; that it would not only provide a new profession for the young men and women of America but of the entire world. In a period of less than fifty years with the typewriter, the business world has advanced farther than it had in as many centuries without it. The busy man of affairs is no longer compelled to put down his ideas in handwriting or to decipher the illegible scrawl that invariably results from the haste and press of active business, nor does he lose the many excellent ideas that are crowded from his mind before he has time to record them. The modern typewriter has supplied a means of making correspondence easy, quick and legible. By economizing the time of the thinker and writer no invention has appeared since the art of printing that has done so much to promote the general spread of intelligence as the typewriter. Many of our great inventions have been the result of accidental discoveries — the by-products of thought and experiment seeking other results in a more or less related line of investigation. So it was largely the efforts of early inventors to produce devices for making embossed letters for the use of the blind, and to perfect telegraphic printing machines that gave impetus to the idea of a writing machine. Such important inventions come into existence by slow stages of development and many acute minds were destined to combine their efforts before a successful writing machine was devised. The typewriter had been in process of evolution for more than a century and a half before that, but in recording the real history of its progress it is not necessary to go beyond the last half century, as it is within this period that the first practical machine was produced and the present high state of perfection reached. It is true that some successes were attained at an earlier date, but these served principally in contributing ideas for subsequent inventors to develop, enabling them to accept the practical and discard the unpractical.

Phonography, that is, the representation of words as they are pronounced (from the Greek words meaning "sound" and "write"), was one of the great inventions of the nineteenth century, a phonetic system of shorthand having been introduced by Isaac Pitman in 1837. As is the case with most inventions, few appreciated its value in its early stages. It is commonly understood as stenography,

The latter, however, is an abbreviated form of writing and was in existence centuries before the system of sound writing was invented. By the aid of shorthand the business man and the writer were enabled to speak their thoughts to some one else instead of laboriously writing them out themselves; yet shorthand was but a halfway measure. The stenographer could take letters or manuscript as fast as they could be dictated and could save the employer much time, but could not transcribe what he had taken any faster than he could drive his pen. Something more was needed — something that would actually cut the time of writing to one-half, one-third, one-quarter, according to the skill of the writer. Hence, the typewriter was required to perfect the scheme that has so efficiently economized the time of thinker and writer.

The earliest evidence of an attempt to produce a typewriter is found in the records of the British Patent Office. According to these records a patent was granted in the year 1714 to Henry Mill, a noted English engineer, for a machine intended to do writing. In those times it was not customary to attach drawings to patents, so that no more is known about the device than what is briefly described in the specifications, namely, that it was a device intended "for the impressing or transcribing of letters singly, or progressively one after another, as in writing, whereby all writings whatsoever may be engrossed on paper or parchment so neat and exact as not to be distinguished from print." But the brief description is sufficient to show that Mill's invention embodied the fundamental conception of the typewriter as we know it today. No record of the construction of this machine has ever been found, so that we must conclude that, like many other important inventions, this early attempt was abandoned and that the idea passed entirely out of mind with the inventor and was not revived until many years later. In 1784 a machine was invented for the purpose of embossing printed characters for the blind. Of this machine, also, nothing is now known, and its importance is doubtful.

The first American typewriter

The first American typewriter of which we have record was the invention of William Austin Burt, of Detroit, who in 1829 took out the first United States patent ever issued for such a machine. It was called a "typographer". The letters of the alphabet were arranged on a segment and corresponding notches acted as an index. A lever which could be worked up and down and also moved laterally was provided with a series of type arranged in a segmental curve so that any type could be brought into place on the paper by swinging the lever around and down into the proper notch in the index segment. Although an actual working typewriter, it was of the roughest construction and crude in the extreme. The record of this patent, together with the original model of the machine, was destroyed by fire in 1826, but a restored model and a copy of the patent is now to be found in the United States Patent Office.

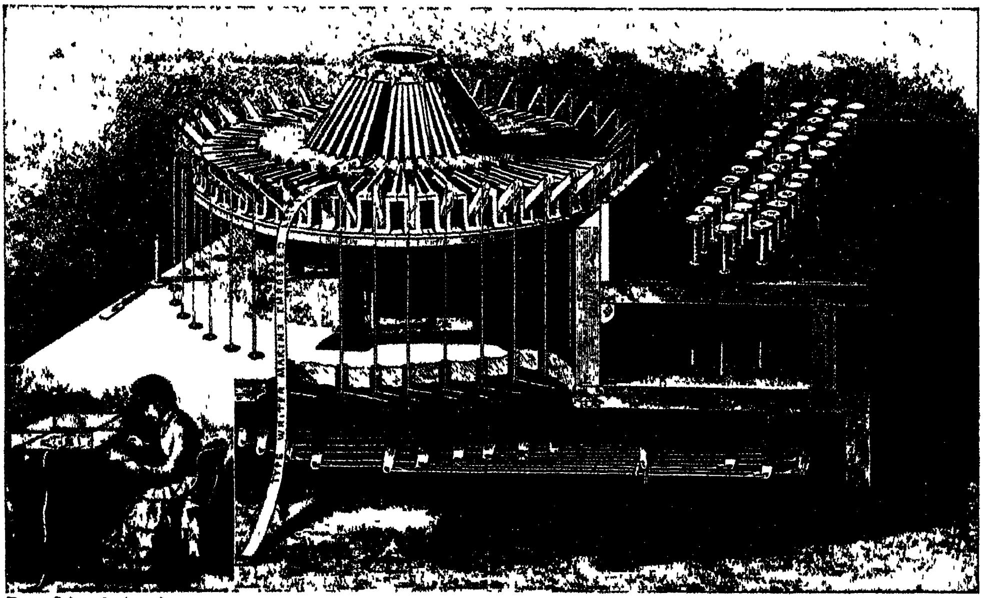
First machine with separate key levers

To Xavier Progin, of Marseilles, belongs the distinction of inventing the first organized typewriter in which separate key levers were provided. It was called a "typographic machine" and was patented in France in 1833. This machine was also crude in design and awkward to use. Upright key levers were arranged around a circular plate, and pivoted to the shanks of type hammers, to raise and lower them. The hammers were inked from a pad and delivered a printing below on the paper which was held stationary below the machine. The whole nest of levers was moved over the paper as each letter was printed.

In addition to printing letters the device is said to have been used for printing music and for making stereotype matrices. The records of the British Patent Office show that in 1840 Alexander Bain and Thomas Wright made application for a patent on a machine for use in connection with the telegraph, and these men were afterwards known as the inventors of a telegraphic printer. Bain's device proved to be of no use as a typewriter.

Between 1840 and 1850 several typewriting machines were invented in England, but, like many of the earlier efforts, they were designed primarily for producing embossed letters for the blind, or, more especially, for purposes of the electric telegraph, and, as such methods of telegraphy were soon superseded, these inventions attracted little attention. These machines embodied some of the principles of the modern typewriter, but none of them passed beyond the experimental stage.

In America, however, Charles E. Thurber of Worcester, Massachusetts, invented and patented in 1843–1845 a machine that did actual work. This was a type-wheel machine operated by a combination of type bars around a large circle. It was large and clumsy, but it is entitled to much credit for having suggested the first principle of the movable carriage, a feature embodied in all modern machines. This machine was slow but it did fairly good work and the original model is now on exhibition in the hall of the Antiquarian Society at Worcester.



From *Scientific American*

THE ORIGINAL TYPEWRITING MACHINE
Which was awarded the gold medal of the American Institutes in 1856

Perhaps the inventor who aroused the greatest interest about this time was Alfred E. Beach, editor of the *Scientific American*, who during the period from 1847–1856 did considerable experimenting in an effort to produce a practical typewriter. His machine amounted to little, but the articles which appeared in the *Scientific American* gave impetus to the movement and encouraged later inventors.

The principal novelty of Beach's machine was the converging type bars to a common center, and this feature has been employed in many of the machines invented since that time. It had other good points, such as the letter and line spacing, paper feed devices and line signal bell, and showed marked improvement over previous machines.

Beach was followed by S. W. Francis, a wealthy physician of New York, who took out a patent for a typewriter in which a motion similar to that of a piano hammer was employed to throw up the types, which were arranged in a circle, to a common center. Thus to the Beach principle of a circle or nest of type bars, Francis added the pianoforte action. The machine was intricate and cumbersome, and although capable of good work, was too costly for commercial venture. It was never put on the market, and indeed, so far as is known, but one model was ever constructed.

In 1843 Pierre Foucauld, a young blind man of the Paris Institute for the Blind, produced a machine which was very successful in printing raised letters. Foucauld's typewriter attracted much attention and was awarded a gold medal at the World's Fair in London, in 1851. Several of these machines were constructed and used for a long time in various institutions for the blind in different parts of Europe. They did not come into very general use, however.

The writing ball; a curiosity in the history of typewriting invention

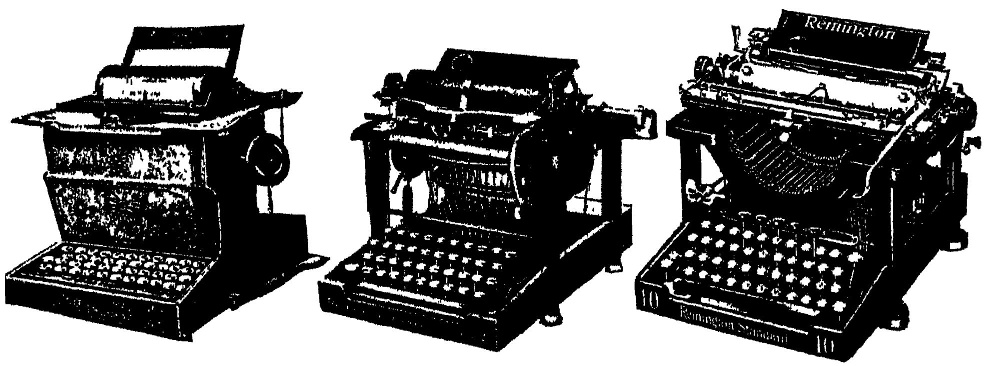
One of the most peculiar typewriter inventions known in Europe was the writing-ball, invented by a clergyman of Copenhagen, a Dane named Hansen. This machine consisted of a hemispherical brass shell inverted over the paper-carrying and spacing mechanism. Through this shell radiated a number of rods from different directions toward the common printing point which was the center of the sphere The machine was light and small and did good work but it was too costly and too slow in operation for commercial success. United States patents were issued upon this machine in 1872, and in 1876 it was awarded a gold medal at the Centennial Exhibition in Philadelphia. However, it is known in this country only as a curiosity.

Business growth in the last century urgently demanded an efficient machine

Numerous patents were issued from time to time representing various attempts to produce a machine that would be acceptable to the public, but none of these up to 1867 demonstrated any marked progress toward a practical typewriter. A writing machine had not yet come to be regarded as of any special value to the business world, as business had not assumed its subsequent huge proportions requiring the aid of such a device. But when the wonderful progress and prosperity of the latter part of the nineteenth century necessitated a radical change in business methods, our men of genius were equal to the task, and its production was not long delayed.

The man who first brought out a practical typewriter and made it indispensable to the modern business world was Charles Latham Sholes of Milwaukee, who in 1868 took out patents on models which formed the working basis of the first typewriter that ever went into office use. Associated with Sholes, who was a printer and editor, was Samuel W. Soule, also a printer, inventor and farmer, and Carlos Glidden, who at that time was engaged in an entirely different field of invention Sholes and Soule were jointly engaged in the construction of a machine for serially numbering the pages of blank books, etc. The three men were thrown in daily contact in the same machine shop in Milwaukee in which they were having their experiments conducted, and each evinced a keen interest in the other's inventions. It is said that Glidden one day chanced to remark, "Why cannot such a machine be made that will write letters and words instead of figures only?" In this way was the seed of thought dropped without any knowledge at the time that such an invention had ever before been attempted. The suggestion did not bear fruit immediately, but in view of subsequent developments it may be said that in this casual remark the Remington typewriter had its origin Not long after this Glidden discovered quite by accident that a machine had been invented by John Pratt of Centre, Alabama, which was designed to do just what he had suggested. He was impressed with the great benefit to mankind which a machine of this kind would confer, as well as the fortune awaiting the successful inventor He brought this to the attention of Sholes, and it strongly appealed to his imagination. Sholes determined to try what could be done, and as Glidden had first suggested the idea he was invited to join in the enterprise. Finally the aid of Soule was also enlisted. Numerous experiments were made and many devices suggested. Eventually a crude model was constructed which was largely the work of Soule, who suggested the pivoted types set in a circle, and other minor details. Sholes contributed the letter-spacing device.

These machines were placed before the public under the management of the original inventors, but Soule and Glidden eventually withdrew from the enterprise. At first the machine used only capitals, and while fairly accurate and rapid, soon showed that it was far from being perfect Many letters were written on it, and one of these happened to fall into the hands of James Densmore, a wealthy oil and iron man of Meadville, Pennsylvania. Recognizing the great future for such a machine, he purchased a fourth interest from the inventors, paying all the expenses incurred in experimenting up to that time. He made this investment without having seen it, basing his judgment on the fact that it would print legibly and do faster work than the pen. After seeing it, months later, he pronounced the manner of construction a failure but the principles embodied to be correct, and he immediately set about developing them. Numerous models were built and condemned, which discouraged Soule and Glidden to the extent that they withdrew from the enterprise, and had it not been for the constant encouragement of Mr. Densmore, Sholes would have done likewise. After the machine had been perfected to the point that the owners were willing to submit it to the public upon its merits, it was decided to secure the opinion of a disinterested expert mechanic in regard to it and its further development and manufacture.



REMINGTON PROGRESS

Original Remington Model No 1, exhibited at the Centennial Exhibition in 1876, where it attracted much attention but was slow to gain public favor It wrote only capitals

Remington Model No 2, awarded a gold medal at the Paris Exposition of 1878 This machine wrote both capitals and small letters without increasing the size of the keyboard or adding to the number of type bars

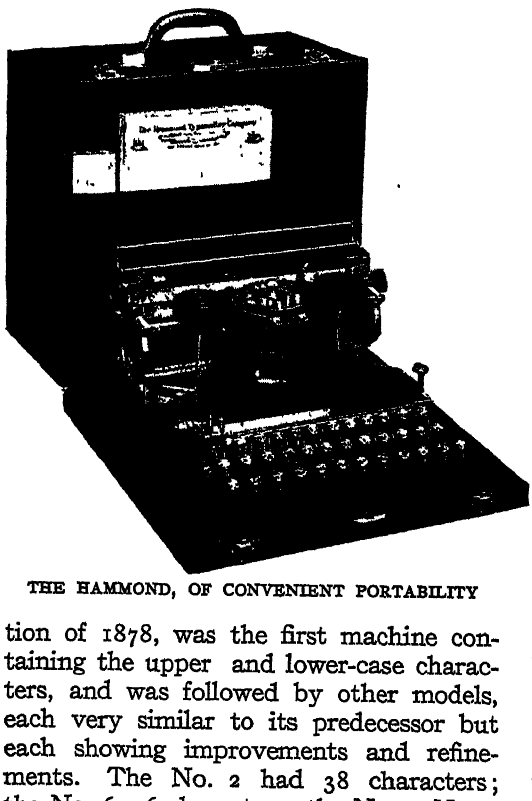
Remington Model No 10, with all the latest refinements, including visible writing. This machine is built with over 1700 different keyboards and to write 184 different languages

For this purpose George W. N. Yost was selected, and after suggesting a few minor changes, which were made, he recommended E. Remington & Son of Ilion, New York, as doubtless best prepared for doing such exacting work as was necessary in constructing the interchangeable parts required. This firm having been engaged in the manufacture of munitions for the Civil War was well equipped with machinery and skilled workmen, and, after making various changes and improvements, built a thousand machines. They also secured the rights to the machine, to which they gave the name Remington. This transaction took place in 1873, and the first model of the Remington typewriter was put on the market the following year.

The manufacture had been arranged for but the distribution was another matter. The public, not being familiar with the typewriter, had to be educated as to its value, and more than a decade passed before it began tc really appreciate its possibilities. The first Remington attracted much attention at the Centennial Exhibition at Philadelphia in 1876. One of the objections to it was the fact that it wrote only capitals, but this difficulty was soon overcome. Lucien S. Crandall conceived the idea of a shift key and Byron A. Brooks that of having two types on one key, a capital and a small letter. The combined ideas of these two inventors made it possible to write both small and capital letters, together with numerals

and other characters. This was accomplished in 1877. The machine manufactured meantime by Mr. Yost, known as the "Caligraph", was a double-case machine — that is, it had a full keyboard, capital and small letters, with a key for each type, the capitals being divided and arranged without regularity on each side of the keyboard. This machine was less popular, but it contributed greatly to the development of the use of the typewriter, as it created the competition needed to arouse public interest.

The No. 2 Remington, which was awarded a gold medal at the Paris Exposition of 1878, was the first machine containing the upper and lower-case characters, and was followed by other models, each very similar to its predecessor but each showing improvements and refinements. The No. 2 had 38 characters; the No. 6, 76 characters; the No. 5, No. 7 and the wide carriage machines all had 84 characters.



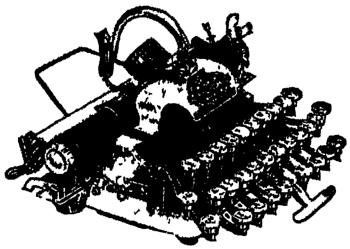
THE HAMMOND, OF CONVENIENT PORTABILITY

The arrangement of the original keyboard was influenced by the fact that Sholes was a printer, and he designed it after the printer's case. But this was found impracticable, as in many instances the type interfered in action to and from the printing point. When the necessary changes were made it was found possible to write to the extent of the one-finger operator's ability, and the manufacturer settled down to that style of keyboard. When the idea of systematic writing by touch was conceived, numerous authors introduced different systems, but all based upon the same arrangement of keys As the advantage of touch typewriting became apparent, a universal keyboard was found desirable, so that the typist could change from one machine to another without change of system.

Radically different in theory and construction from other writing machine inventions up to this time was the Hammond typewriter, invented by James B. Hammond in 1880–1883. Its central principle was the type-wheel, and the difficulty involved in its construction was in the great mechanical accuracy required in order to get the hammer blow delivered at the exact moment that the desired type reached the printing point. The advantage of this construction was that each wheel contained a full set of type and could be quickly changed, enabling the use of various languages and styles of type on the same machine; hence it found a niche in the business world. The wheel has been changed to a shuttle and carries two sets of type. The ideal keyboard for the accommodation of the characters on the shuttle was submitted to the public, but it was not liked, and the universal keyboard was adopted. The Hammond was the first successful type-wheel machine. Its touch was uniform, as was the blow delivered by the hammer, but great speed was not possible except on certain characters.

A wonderfully ingenious little machine is the Blickinsderfer, which is mentioned at this point because it is a type-wheel machine embodying the same principle as the Hammond. This machine did not use a ribbon, but the wheel, in its movement toward the printing point, passed a felt pad from which it obtained its supply of ink. The Blickinsderfer was popular because it was low priced, easily portable and did good work; and the type-wheel, containing different styles of type or char-

acters of other languages could be changed with little difficulty. The manufacturers also tried to introduce a keyboard adapted to the arrangement of the characters on the wheel, but were compelled to adopt the universal keyboard.



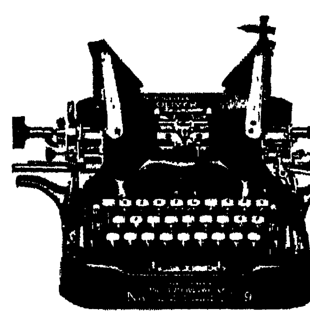
ALUMINUM FEATHERWEIGHT BLICKINSDERFER

The "Bar-Lock" was the next double keyboard machine to follow the Caligraph. For it was claimed visible writing, which was beginning to be demanded, but the writing was not really visible, the operator being compelled to lean forward and peer over the type levers, which was more inconvenient than to lift the carriage to see the work, as was necessary with the other machines that made the impression beneath the printing platen.

The Smith-Premier, placed on the market about 1889, was one of the next succeeding machines, and proved to be very effective not only because of its construction and good work, but because of the method by which it was marketed. This machine was of the double keyboard variety, that is, a key for each character, but it differed from the Caligraph, and was an improvement over it, in that the keys in both the capital and small character cases were arranged alike, one just above the other in the same relative position. The bearings of this machine were long, which helped to preserve the alignment, and the platen tilted forward, when it was desired to see the work, which was more convenient than the old way of lifting the carriage. This machine was provided with an automatic ribbon reverse with an arrangement for the use of a tri-colored ribbon which might be shifted by a lever from one color to the other, and with a convenient means of cleaning the type. By removing the platen, an easy operation, and inserting a crank handle down in the type-well, connection was made with a circular brush, which was always in position. The turning of the crank raised the brush and all the type were effectively cleaned at one time. This was a great improvement over the old way of raising the carriage and lifting each key, individually, in order to brush it, resulting not only in soiling the hands, but also in frequently missing some of the type.

There had been a number of attempts up to this time in the development of the typewriter to obtain visible writing, and many manufacturers had tried to obtain it, but without any great success: for example, the Bar-Lock, already referred to, with its leaning of the operator's body forward instead of a hand movement to raise the carriage; the Hammond, which required pushing down the ribbon control to see what had been written; the Williams, the type-bars of which had what was known as the "grasshopper" movement, coming from each side of the platen and giving but one visible line which immediately passed from view; the Oliver, invented about 1893, which showed the last ten characters written, but necessitated the movement of the carriage back and forth to see the full line or more. None of these methods was satisfactory.

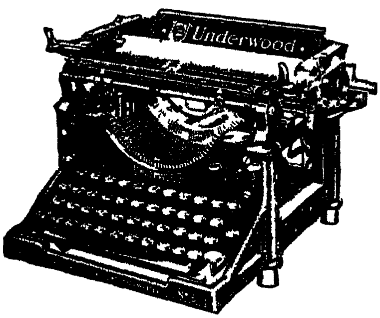
About 1894 Franz X. Wagner, who had been associated as an inventor with the typewriter industry since its earliest days,



THE FIRST "VISIBLE WRITER"

invented a type-bar mechanism which provided for a front stroke. The earlier machines had been manufactured on the principle of the under-stroke, that is, making the impression beneath the cylinder, out of sight. Later manufacturers who

sought to produce visible writing made their type-bars strike downward on top of the cylinder, but each possessed mechanical difficulties which prevented the typist from seeing the writing The invention of Mr. Wagner not only greatly simplified the construction of the machine, but made it possible to see every character written on the page and kept it constantly in sight, from top to bottom. Mr. John T. Underwood, from whom the machine which embodied this improvement gets its name, secured the controlling interest in it and immediately set about refining and developing it. The front-stroke machine reversed the old and established new basic principles in typewriter construction. In addition to giving completely visible writing, the type lay in a semicircle, face up, just above the keyboard, where it could all be thoroughly



THE UNDERWOOD NO. 5

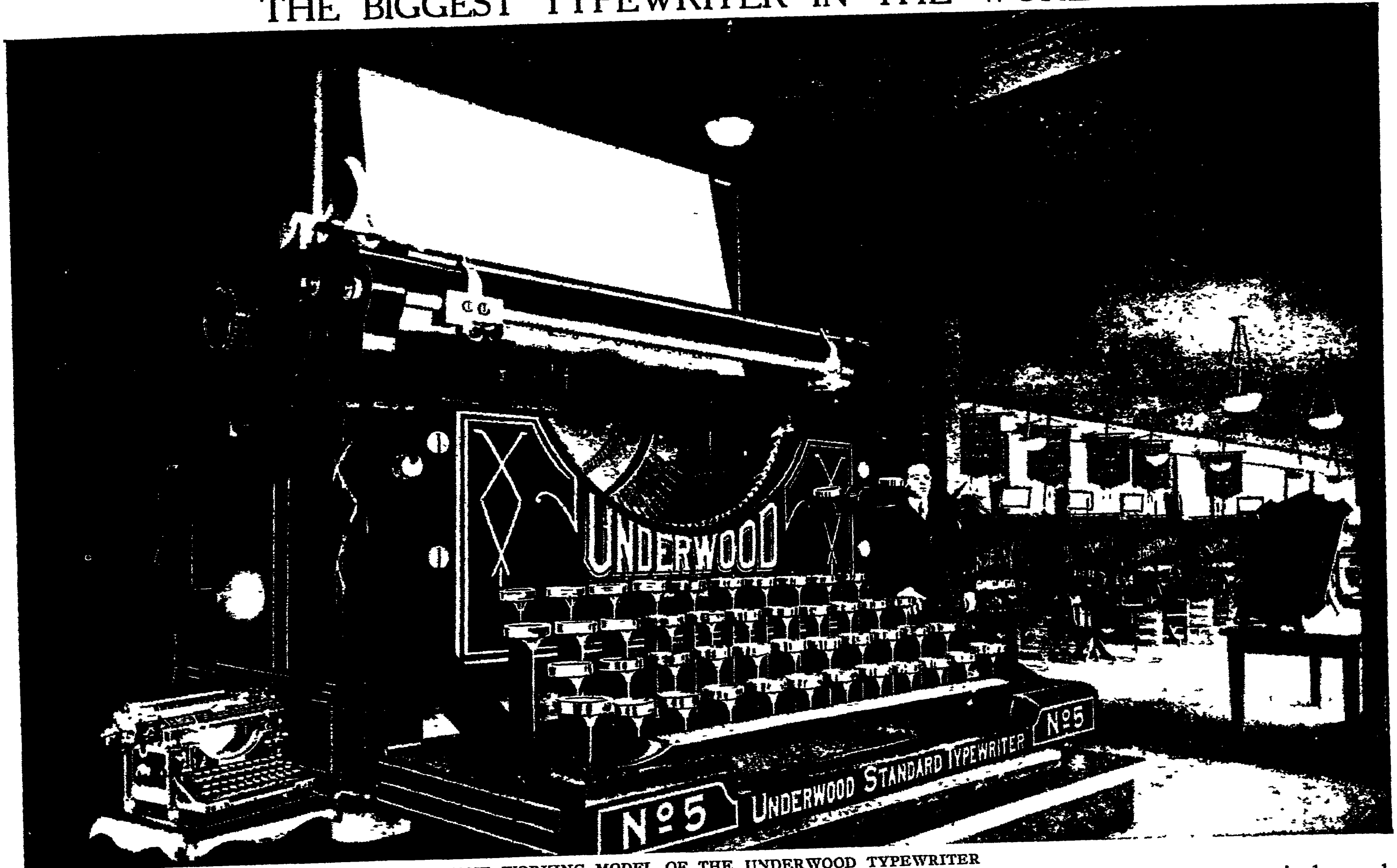
cleaned with two or three strokes of the brush. These type-bars hang in a segment on a single steel type-bar bearing. They strike upward into an adjustable guide and the type-bars may be removed instantly, the bearing cleaned and the bars returned without interfering with the alignment.

The complete visibility of writing, as well as other features, the value of which was immediately recognized by the public, caused the Underwood to meet with instant favor, and led to a remodeling of all the leading typewriters to secure the same end. The extent to which the public appreciates the typewriter today is indicated by the fact that one of three plants of the Underwood Company has a floor space of twenty acres.

Every improvement is introduced to promote system and convenience in construction. In the best factories it is divided into sections, and the work is done with such accuracy that should a defect develop several years after the machine has been sold, the cause can be traced to the individual responsible for it. As the average typewriter is composed of 3000 odd parts, an almost infinite variety of mechanical operations are necessary before a complete machine goes forth from the factory in perfect working order First the main framework which supports the mechanism is cast in one piece in a foundry in which unusually high-grade workmanship is required. After a thorough cleaning, in which all imperfections incident to molding have been removed, the frames are sent to the transferring department, where they are given the required finish and where decorative work, the name and style of machine or other printing, is transferred to the finished surface by means of stencils.

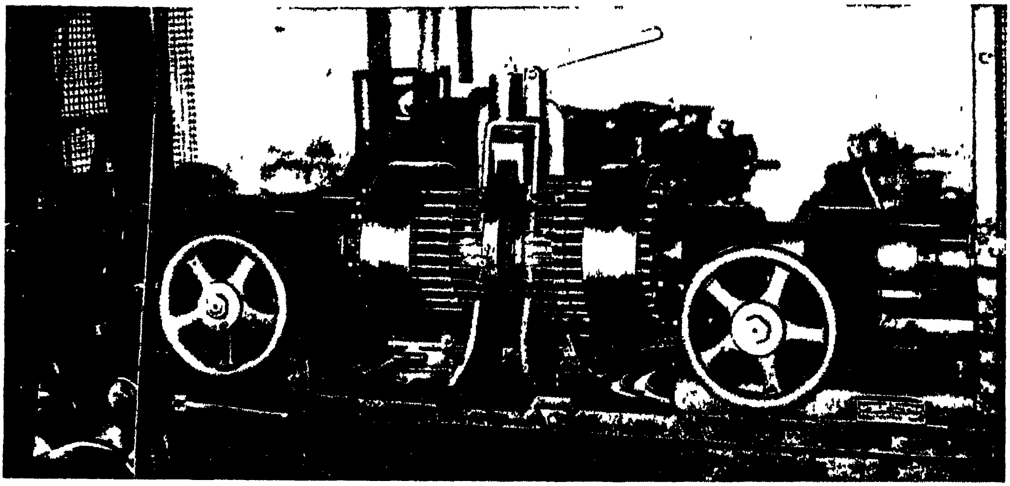
To each frame is given a working or shop number, a card is attached to it, and the part that each employee plays in its construction is indicated by his signature on the card. When the machine is ready for sale the selling number is placed thereon, thus making it difficult for a stolen machine to be hidden any length of time, as the secret or shop number will indicate the identity of the machine although the sales number may have been defaced. While the frame is in process the heavier parts of the mechanism which the frame supports are being formed by punching machines in the heavy punch press room, while the smaller and lighter pieces, some of most intricate design, are turned out in immense quantities on the lighter punch presses and in the automatic screw-machine department. So skilfully made and accurate are the dies used in the punching machines that the many small parts fit into their places in the machine without further operations being performed upon them. A few of the parts, however, such as the type-bar ring, require certain milling operations before they are ready for assembling.

THE BIGGEST TYPEWRITER IN THE WORLD



GIANT WORKING MODEL OF THE UNDERWOOD TYPEWRITER

The man at the right and the ordinary No. 5 machine at the left give an idea of its size. It writes only capitals, and the pressure required on each key is the weight of a man. It is used on posters, but is of course really for advertising purposes, and is so exhibited on the pier at Atlantic City.



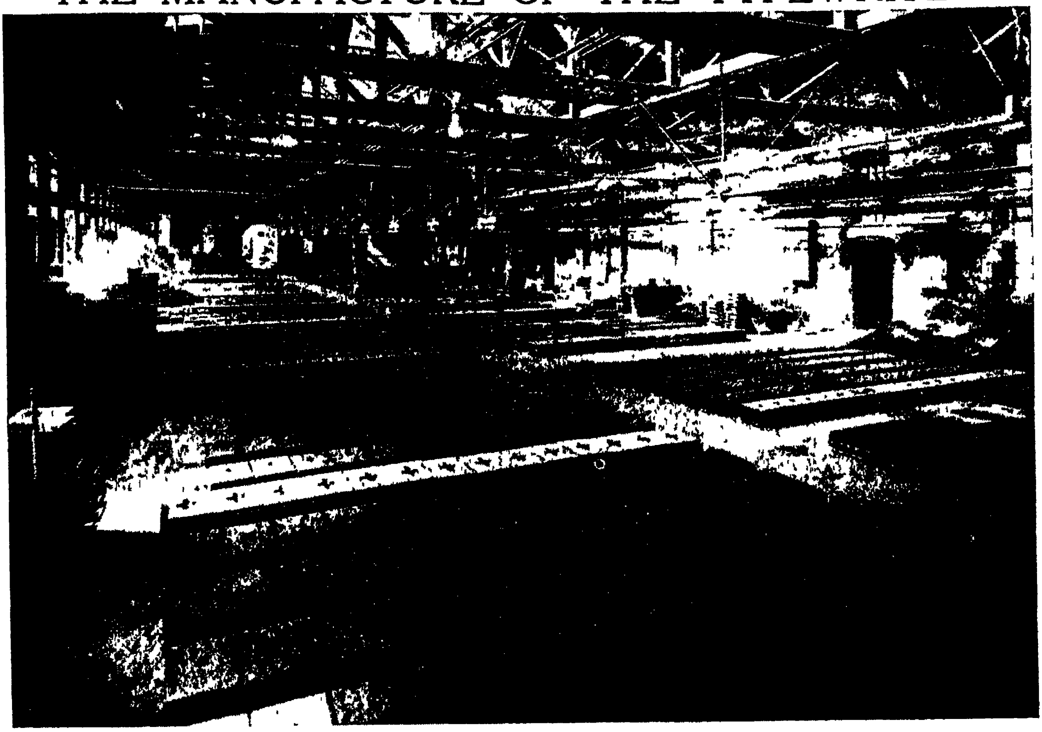
ONE OF THE REMARKABLE MACHINES WHICH AUTOMATICALLY DRILLS THE FRONT AND BACK SEGMENTS OF THE TYPEWRITER MECHANISM

It is interesting to note that the many small parts of which the typewriter is composed are produced almost wholly by automatic machines. Small screws, pins, rivets, etc. are automatically produced from bars or rods of metal fed into machines which seem almost human in their operation. Among the most remarkable machines to be found in a typewriter factory are those which automatically form the various kinds of type required on the modern typewriter. Characters of great variety and in many languages are accurately formed in large quantities and with such ingenious mechanical movements as to astound the observer. The most delicate and accurate work required in making a typewriter is that which has to do with the ball-bearing joint of the type-bar mechanism. It is estimated that ninety-eight per cent of the operator's time is consumed in tapping the keys, shifting to write capitals and returning the carriage to start a new line. As friction and wear would otherwise develop, each of these operations is made easier and more accurate by the use of ball bearings. The machines which form the runways in the type-bar ring with such extreme accuracy and those which form the small hardened steel balls and sort them to limits of one ten-thousandth of an inch, are among the most wonderful that can be found in any industry.

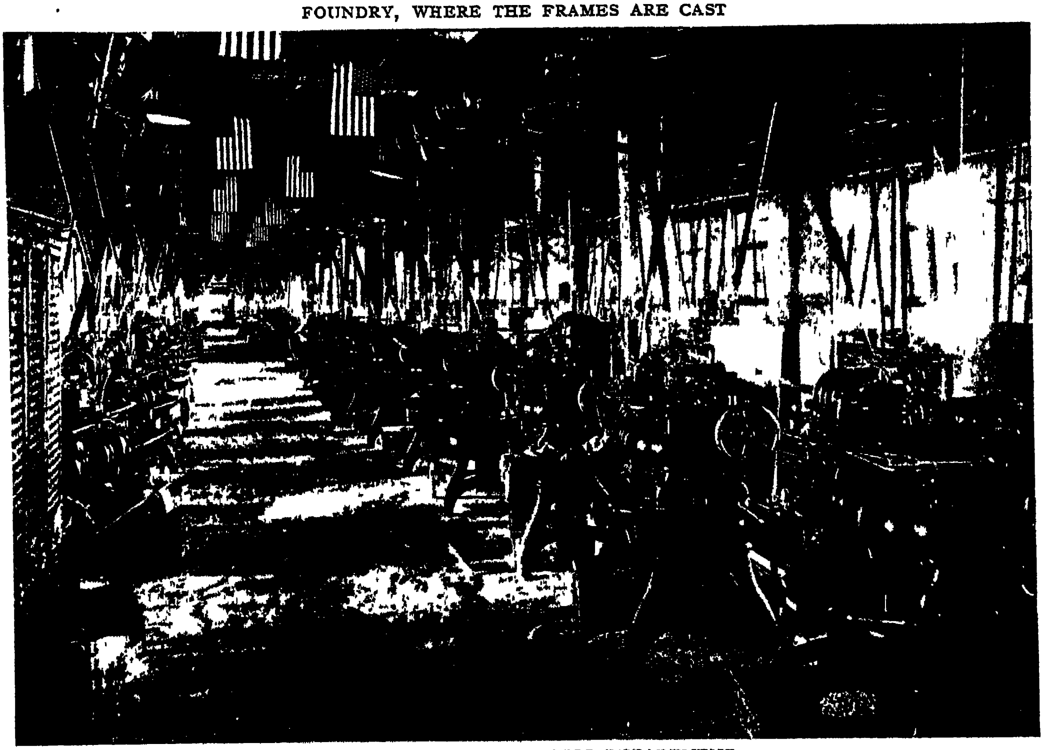
It is evident that a machine composed of so many small and intricate parts could not be conveniently assembled by bringing together all the parts in one place and placing them in their relative positions. As the various parts are completed in the factory, they are removed to the stock-room and systematically grouped in such a manner that they can be conveniently secured as needed for the assembling operations From the stock-room the parts are sent as needed to the room where the typewriter is assembled into its elements. In this minor assembling great skill is essential and many ingenious devices for performing these operations are required. The assembled parts are next passed to the erecting room, where the machine as a whole is put together. After the final assembling the machine must be carefully tested, adjusted and inspected before being packed for shipment. Perhaps the most interesting process which the typewriter must undergo at this stage is that of exercising the keys. It is connected up with an ingenious mechanism which causes each key to be struck many hundreds of times just as it would be struck by the operator in actual use.

Typewriters are now constructed for practically every purpose, their field of usefulness having been extended to include bookkeeping by the development of a machine adapted for writing on the page

THE MANUFACTURE OF THE TYPEWRITER



FOUNDRY, WHERE THE FRAMES ARE CAST

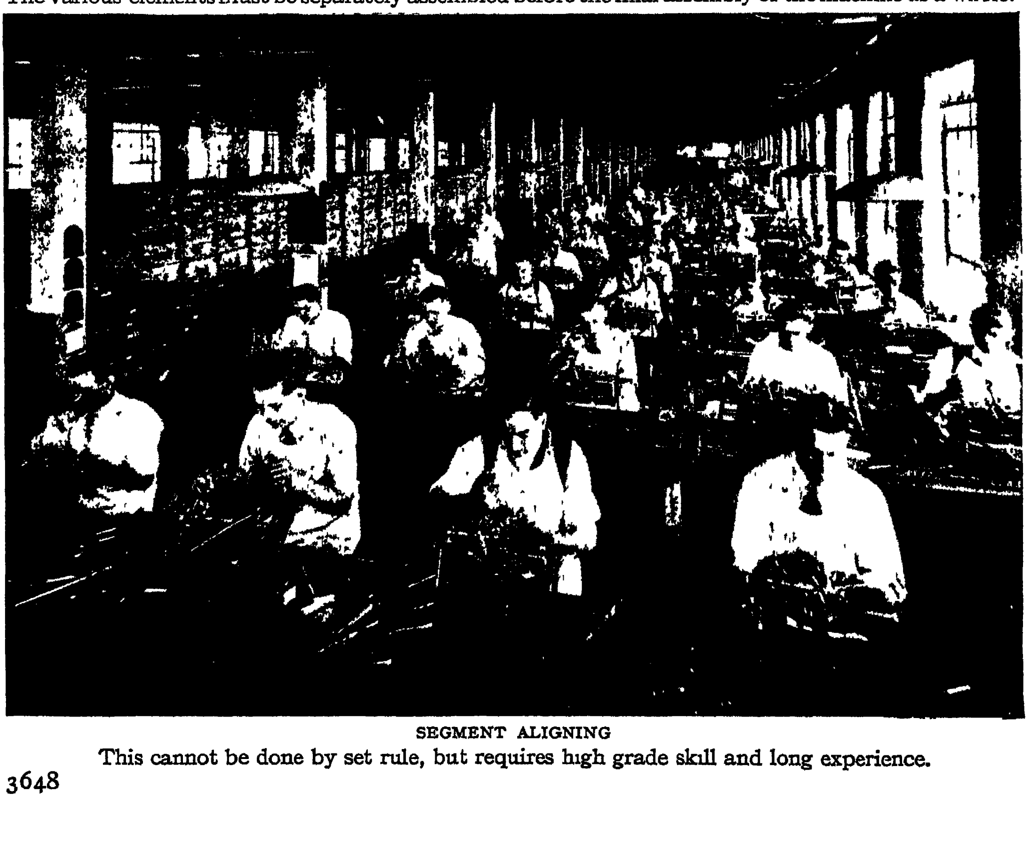


AUTOMATIC SCREW MACHINE DEPARTMENT

Where the hundreds of small parts that go into the make-up of a typewriter are automatically produced in immense quantities and with great rapidity and accuracy.

ASSEMBLING KEY RINGS AND CARDS

The various elements must be separately assembled before the final assembly of the machine as a whole.



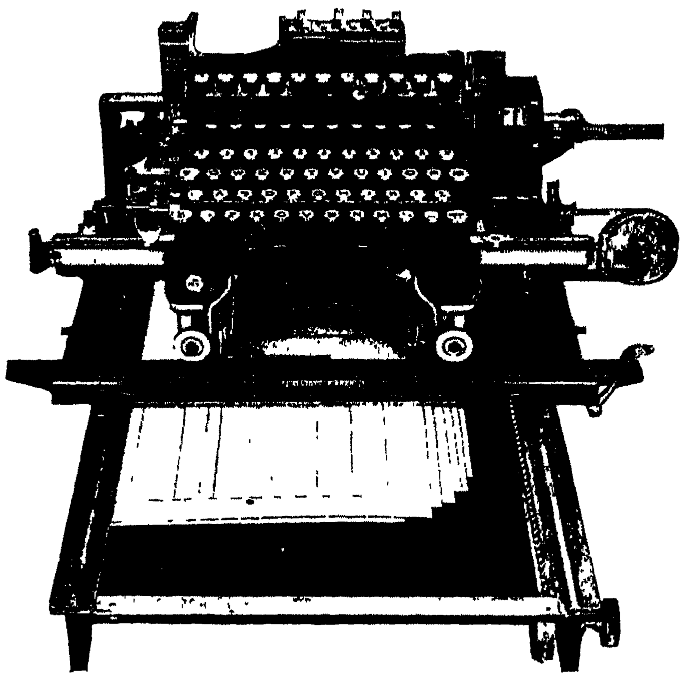
SEGMENT ALIGNING

This cannot be done by set rule, but requires high grade skill and long experience.

ASSEMBLING THE ADDING MACHINE
Here the many intricate parts of this accountant's aid are put together in a completed whole.

ERECTING DEPARTMENT
Here the typewriters are finally assembled, tested, inspected, and made ready for shipment.

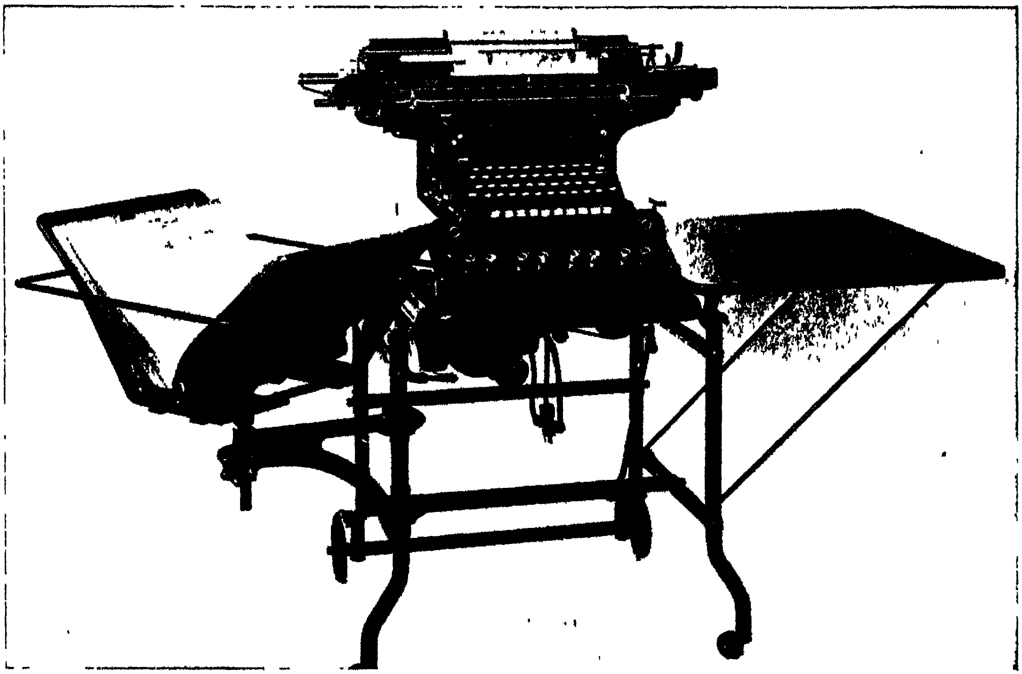
of a bound book, such as a ledger The first machine of this type was the Elliot & Hatch book typewriter In the operation of this machine the page of the book is clamped between the platen and an open frame which holds the paper smoothly in a stationary position. The machine proper, consisting of frame, type levers, etc. slides on this frame and moves up and down so as to space the lines properly, the keyboard with the type-bars, ribbon, etc. traveling step by step across the page A great deal of ingenuity has been expended upon devices of this nature, with the result that we now have modifications of ordinary typewriters whereby tabulating and adding mechanisms are supplied so that not only billing and tabulating, but all commercial bookkeeping can be done on the machine used for ordinary correspondence. The Elliot-Fisher billing and adding machine, patented in 1906, one of the first of these, is a refinement of the Elliot & Hatch book typewriter.



THE ELLIOT-FISHER BOOKKEEPING MACHINE
The bills or other forms lie perfectly flat on a stationary writing surface The mechanism and keyboard move naturally, as does the hand in writing, over the work

The first Underwood typewriter contained the first basic principle of the tabulating device, which has added materially to the ease with which tabulating and statistical work so necessary in bookkeeping can be done. In 1907 the Remington adding and subtracting machine appeared, and was followed in 1915 by a most elaborate and highly perfected machine. Other makers have brought out similar bookkeeping and adding and subtracting typewriters for which certain advantages are claimed These latest and most recent developments of the typewriter have completely revolutionized bookkeeping and accounting, for these remarkable machines are able to list the items and to add, subtract or cross add In addition, manifolding is readily and conveniently secured by adapting the work to the ordinary copy press; the use of carbon paper for making several copies along with the original, or by the use of a special kind of wax sheet stencils may be made whereby an indefinite number of copies may be secured on a mimeograph machine. This is a feature which is now indispensable in dispatching the vast volume of correspondence involved in modern business. Among the more recent adjuncts devised for facilitating correspondence with the typewriter may be mentioned the use of the phonographic dictating machines, whereby any qualified typist is able to transcribe letters or other spoken communications dictated into the machine at some previous time Quite recently attempts have been made to produce power typewriters, in which the impression mechanism is operated by magnets when the operator closes the circuit by touching the key. The advantages claimed are uniformity of touch combined with ease and rapidity. Several patents have been secured, but so far electrical typewriters are in an experimental stage and have not come into general use.

Though there are numberless differences in detail, it is seen the great majority of typewriters fall into two general classes: type-bar machines, in which the types are carried on the end of levers or type-bars which strike the paper at a common printing point when the keys are depressed; and type-wheel machines, in which the types are arranged around the circumference of a wheel, or segment, which is rotated by the action of keys until corresponding type is brought around to the printing point. The type-bar machines are by far the most common Another point each key does duty for two or more characters, accomplished by means of shifting mechanism. The opinion of operators is apparently divided as to the relative merits of these two methods. Different machines present, in addition to the above leading features, greater or less ingenuity in devices required for practical convenience, as well as for durability and easy repair and maintenance in good condition. Many of the subsidiary appliances and attachments that have been devised are of advantage, while unquestionably some are more useful for advertising purposes in

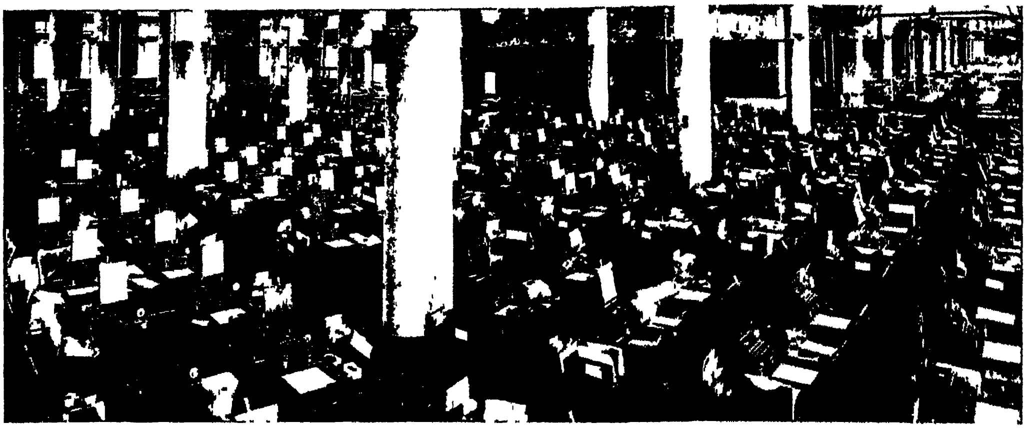


THE UNDERWOOD BOOKKEEPING MACHINE

in which typewriters generally differ is in the method of inking. In most cases the type marks the paper through an intervening ribbon saturated with appropriate ink. Various ingenious methods are employed in properly arranging the ribbon to secure the best results. In some cases the type rests normally against an ink-pad and the type prints directly on the paper. A third basis of classification may be noted in the arrangement of the keyboard. Some machines have a separate key for each character, including capital and small letters, while in others the keen competition between manufacturers than to the practiced operator. Visible writing has been accepted as a consideration of prime importance, but perhaps no less important is accuracy of alignment. No typewriter can do satisfactory work unless all characters come precisely to the same printing point. To secure this result, the mechanical problem of confining in a much restricted space a strong, rigid and light system of levers, supported on bearings steady and adjustable for wear, has given wide scope to the ingenuity of inventors.

There has been a great foreign demand for American-made typewriters, and they are exported to all parts of the world. The great majority of machines used in Europe are of American manufacture, and the value of our exports constitutes practically one-half of the entire output of the country Among European countries Great Britain is our best customer. Next to the leading European countries come Mexico, Australia and Africa. These are followed by the Philippines, British East Indies, Cuba, Japan and China. In South America Argentina is our largest buyer, Chile next and Brazil third.

It will be seen that within the comparatively brief period of half a century the typewriter has revolutionized business A characteristic American labor-saving invention, its use was at first practically confined to court stenographers, lawyers and the larger business concerns. But now it has become indispensable in practically all lines of business and many forms of social activity. Smaller concerns have been forced to follow the lead of the larger ones in order to secure the same attention to their letters, so that the typewriter is now found everywhere in business to the practical exclusion of handwriting in correspondence. In the armies in the field, the typewriter was an important part of headquarters equipment, and even in the trenches the small portable machines found favor for private correspondence. The gain in time for transcribing and reading letters and records is remarkable. The average operator can write some 100 words a minute, or about three times as fast as the average penman, while in speed competitions by expert operators, a record of 144 net words a minute for one hour has been established after ten words for each error had been deducted. The minute record, without error, is 170 words. The rate of speed at which these records were made is interesting and proves quality of construction. Over 12 strokes a second was responded to by the machine in the one-minute record, while the average was over 11 strokes a second for the hour. These rates of speed are given to show the extreme accuracy of the machine, because skipping, piling or impinging of characters is penalized at the rate of 10 words for each. It must be understood also that for every stroke of the finger-key, the type-bar makes two distinct movements, forward and backward, and the same is true of the escapement mechanism.



A LARGE MAIL ORDER DEPARTMENT EQUIPPED WITH ELLIOT-FISHER BILLING MACHINES FOR SINGLE ORDER ENTRY WORK

The typewriter has a paradoxical effect upon business. It lessens labor and at the same time increases it; it takes the place of the pen in business correspondence, yet good penmanship was never in greater demand than it is today; it magnifies mistakes in spelling, punctuation, capitalization and composition and as a result leads to their correction. The typewriter has done more to promote the wonderful increase in business during recent years than any other office device.

PRESENT GOVERNMENT PROBLEMS

American History Has Given Us Many Ideas and Institutions but Ill-Suited to Modern Conditions

THE ORGANIZATION OF DEMOCRACY

AMONG the many remarkable things about our country none is more striking than the way in which a long course of social evolution has been telescoped, so to speak, into a short period of time The interval from frontier to urban conditions has frequently been less than the span of a single life, and indeed the two have existed at the same time within a day's journey of each other. It was but natural that a political organization framed to fit the needs of a small nation of backwoodsmen and farmers with a small proportion of traders in the few small cities should rapidly get out of date as that nation increased in population and wealth, industry and commerce, until it outstripped all other civilized nations in the world. And this is what has happened to us in a little over a century Though, as a whole, we are still rural in comparison with some of the older and smaller countries of Europe, the metropolis of America is now the largest city in the world and represents the greatest concentration of population and business.

Many features of our political history have helped still further to exaggerate the effects of the phenomenally extensive and rapid growth of the country. The fact that the original states were colonies of England at a time when England itself was in the throes of political change, and the circumstances of the long struggle for American independence, greatly accentuated the peculiar political ideals and sentiments of the first citizens of the new Republic. In the first place, as we have already pointed out, the settlers who came to America were predominantly the free-spirited, adventurous, non-conforming and independence-loving elements of England and of the other countries which contributed to the population Most of them came here seeking refuge from some sort of oppression, religious, political or economic. And all the circumstances of colonial life contributed to develop the same characteristics. The exclusion from intimate social relations and the economic self-sufficiency characteristic of the frontier would naturally make any considerable amount of government superfluous if not distasteful.

The fact that to the colonists government in any sense beyond local enforcement of order meant foreign domination helped to make it repugnant. For England itself during much of this period was under the "divine right" government of the Stuart kings, and even after England as a nation advanced beyond that stage through the Puritan revolt and the "glorious revolution" of 1688, she still tried to apply that policy to the colonies Parliament, representing the landed and commercial classes of England, thought that colonies should be a sort of communal preserve of the mother country, to be manipulated at the will of the latter and exploited in her interest. Their function was to supply on demand and at the lowest possible cost those commodities which could not conveniently be produced at home, and to accept in exchange those which it best suited the mother country to furnish. Their commerce was a national monopoly, to be exploited to the political as well as to economic aggrandizement of the home country or used as trading stock in her dealings with other nations.

This to be sure was the theory more than the practice of the home government. Harshly oppressive measures would have frustrated the strong efforts which were necessary to induce people to migrate to and develop the colonies. The policy of government interference in trade and the stimulation of commerce was universal in that period, and, too, the colonists received many advantages in exclusive markets, and bounties and the like from the restricting regulations Many laws which were stringent in their terms were also very laxly enforced, and numerous measures which aroused the strongest opposition were really in the interest of the colonies themselves if they had been far-sighted enough to see it Still others were intended to be onerous and merely represented the mistaken policy of the age of mercantilism, though they probably damaged Englishmen at home as much as they did the colonists. But men fight over small matters when a principle is involved, and the attempt to maintain this theory as to the relations of the two peoples, and to put it into execution when occasion offered, not only led to a separation from the mother country, but also engendered in the minds of the colonists a strong distrust of government and of authority generally.

The suspicion and hatred of executive power during the formative period

Much light can be thrown on some of our present troublesome problems by remembering the relation between the legislative and executive powers with which the American of the early national period was familiar. The colonies had their own elected law-making bodies, but the executive power was lodged in a governor not of their choosing but generally appointed by the king. These governors constantly quarreled with their legislative chambers, and though they were about as often in the right as in the wrong, they naturally came to be associated with the hated yoke of British oppression. It was natural to associate the executive function with oppression from without and above and to look upon the legislature as the popular or democratic department of government. The same tradition in a large degree was inherited from England, where the struggle for democracy took the form of a contest between Parliament and the hereditary executive, the king When the English rule was thrown off, the legislature of course continued intact, while the executive simply disappeared and the representative bodies were left in complete control. Some reorganization was of course necessary, and the state governments needed some sort of a head, but whether the new constitutions were drafted by special conventions or simply enacted by the legislatures, they showed great reluctance to set up a new despot in place of the one deposed The people were not able to grasp the idea of a democratic executive, and in fact the American people have not yet adequately got hold of it.

The lesson partly learned from the failure of the Confederation

Equal to their distrust of executive power was the distaste of the people of the newly liberated states for centralization. Both were looked upon as external, as government from without, and as coming from above, not up from the people as their idea of democracy demanded The states had of course been entirely separate politically, only loosely organized for joint prosecution of the war, and were very jealous of their separate sovereignties Men thought locally and not nationally, for much the same reasons that they thought individually and not socially and distrusted government in general. The result was that the first common government set up by them, the Confederation, actually had no executive. It was only a legislature, a Congress, with no power to enforce the measures it might see fit to pass.

Possibly this arrangement was fortunate in the end, as the completeness of its breakdown went a long way toward showing the people the first requirements of effective political organization. The reaction from this period of separatism and chaos, combined with several historical accidents, procured for the country our present Constitution, in which the fundamental powers

necessary to government are adequately provided for. Indeed, it was so far ahead of the state governments on which, together with English precedent, it was modeled, that they have not yet caught up with it At the same time it is true that the powers of the federal government are definitely limited, that its keynote is the idea of checks and balances, and that the predominance in it is given to Congress and to the federal courts whose character and functions are under Congressional control.

Our Constitution adopted against the opposition of the newer farming states

The Constitution was adopted in the face of great opposition, and was carried against opposition of the newer and more agricultural portions of the states by those which were older and more commercial. It is doubtful if it could have been adopted if on many important points it had not been quite ambiguous The confused ideas prevalent on the subject of democratic government are well shown by the stipulation in its adoption that a Bill of Rights must be added by amendment. The people did not grasp the idea of a government of and by themselves but persisted in looking upon it as a kind of external authority, and hence sought to guarantee themselves against oppression by the formal limitations upon the powers of government embodied in a Bill of Rights No sooner was the new Constitution in force than a struggle began between strict constructionists and liberal constructionists from which the former emerged generally victorious. The general government was to be accorded the minimum of power and any authority conflicting with it was given the benefit of every doubt. The circumstances under which our government was founded thus explain the two main difficulties of our present political situation, the lack of power in the national government to deal with national problems, and the lack of effective administration of law in both state and nation

Under the Constitution the ordinary operations of government, outside of such distinctly national functions as international and interstate relations, the mail service and the like, were left in the hands of the states. The state government is the government with which the citizen comes in contact; outside of the post-office and the internal revenue stamps on a few articles, he need hardly know in times of peace of the national government's existence beyond what he reads of it in the newspapers. The civil and criminal law governing the ordinary relations of life is state law and the central authority has no more to do with its enforcement or interpretation than with its production.

The failure and emasculation of the state legislatures

Now in the states the governor has only a small fraction of even the limited authority given the national executive. The heads of the executive departments are elected, not appointed as are the members of the President's Cabinet. Their duties are prescribed by law and the governor has usually no more authority over them than has any private citizen; he can call them before the courts, or perhaps the legislature, for dereliction of duty or any serious offense, but so can any citizen. The real power in the state government was nominally the legislature. But very early the legislatures began to show themselves both incompetent and corrupt Partisanship, favoritism, wire-pulling and even bribery marked their dealings with every sort of important question. Charters of banks and corporations were treated as political spoils, and even sold outright. Extensive internal improvements were undertaken, but the money disappeared through graft and incompetence and many of the states then repudiated the debts contracted in the operations. The public credit was often extended to corporations undertaking wild schemes.

In consequence of such experiences the people everywhere began restricting the power of the state legislatures. They are now generally forbidden to charter corporations by special act, and the terms of incorporation may even be laid down in the constitution itself They are nearly always prohibited from trafficking in the credit of the state. Almost every imagin-

able device has been tried, and countless prohibitions laid down Many states in desperation have pared the time of the sessions down to a minimum and forbidden the legislature from meeting more than once in two years. Constitutions have grown to fair-sized books, mostly legislative details that have no proper place in a constitution, regulating matters which should be dealt with by legislation but in regard to which the people are unwilling to trust their representatives. Finally several Western states have resorted to direct legislation through the Swiss device of the initiative and the referendum.

Naturally all this is of little avail. The less responsibility is given the legislatures, the less responsible they feel, and the lower becomes the quality of the men seeking election. The less also is the interest which the people take in the choice of legislators and the firmer the grip on the country of partisan organizations looking only for easy jobs and plunder from the sale of legislation to special interests. Already there are signs of a turn in the tide; people are finding out that making government powerless is not the way to make it good.

The exploded fetich of government by laws: necessity of personal discretion

In short, the theory on which we have worked throughout a large part of our national history is radically unsuited to a developing industrial nation. It was natural that as a reaction to arbitrary personal rule the people should be unwilling to trust individuals with authority. Power was given at first only to the direct representatives of the people, and when these were found frequently to misrepresent their constituents the substance of power was taken from them and the people attempted the impossible task of ruling directly, through constitutional conventions and imported devices. The idea of a "government of laws and not of men" as an early Massachusetts constitution expressed it, was made a fetich. It was believed that the people, the final source of political wisdom and power, could lay down ultimate principles of righteousness in social relations which should somehow enforce themselves almost automatically. The colonists dreaded the existence of authority anywhere, not merely in a foreign sovereign; it was taxation in general that they objected to, not merely taxation without representation.

This theory might be well adapted to the purpose which called it forth, the prevention of tyranny and oppression And it might have worked well if conditions had remained stationary in the agricultural stage of economic organization and with almost no danger of attack except from the Indians But when conditions are changing general principles are insufficient; they require much interpretation and constant elaboration and even substitution by new and contrary rules. And with the increasing complexity of social organization the maintenance of order has become but a small part of what a government should do for its people under it. A "government of laws", so-called, is wholly unsuited to deal with new situations or undertake any positive constructive program. Laws there must be, of course, but the power which makes them, must have latitude in framing them, and the laws themselves must be so drawn as to give equal latitude to the power which carries them into effect.

How "government of laws" became government of lawyers

Laws do not interpret and apply themselves without the assistance of some human agency. To do this is the peculiar function of the courts, and accordingly courts have been the real government in America. English history already gave them a somewhat peculiar position. During the period when England was being forged into a nation it was ruled by a government which was practically foreign, that of the Norman and Angevin kings. One of the principal strongholds of resistance to the foreign tyranny was the courts, which succeeded in retaining the right to administer the law of the people with a considerable degree of independence. The moderation and conservatism of the courts fitted them well to serve as mediators in times of conflict and change and enabled them

to preserve substantial continuity in the legal and political development of the country. In the struggle between the monarchy and the feudal barons the courts were a nationalizing influence, and in the later struggle of the nation against the divine-right pretensions of the Stuarts they formed one of the main bulwarks of popular liberty.

The peculiar position of the courts in this country

When the colonists came to this country one of the principal heritages of the old civilization which they brought with them was the English common law. Except in Louisiana and a few districts where the Roman law was brought in through French or Spanish influence, this has been from the first the legal system of the United States. It is the peculiar theory of English law that decisions must always conform to "precedent", but that judges none the less exercise much discretion in selecting and interpreting the precedents Theoretically they always "find", never "make", the law of the case. Where no closely similar precedents are available they have no hesitancy, however, in going back to the "principles underlying" previous decisions.

These latter are supposed to be the ultimate principles of justice in human association, but as a matter of fact quite commonly represent the moral sense or political opinion of the judge himself. Each new case is, of course, a precedent for succeeding ones, but subject again to "interpretation"; and thus the law grows. In reality the judges of the courts have been the principal legislative authority of England and America, and a good part of our statutes are a mere codification of case law. Case law always holds until definitely superseded and changed by statute, and many efforts to change it have been wrecked on the judges' opposition to so radical alterations. When the two conflict the statute is supreme, but courts also exert a great influence in modifying statutes in their application by defining, in accordance with common-law precedents, their terms and the sort of cases they are meant to cover.

Effect of written constitution subject to judicial interpretation

In addition to the great power vested in the courts by the very theory of English law, special conditions in America have given them greater and higher authority. In the first place our practice of allowing the courts to pass on the constitutionality of laws places the highest court above the legislature. It is evident that the existence of a federal system of government calls for some such arrangement in connection with the relations of the states to the central power. There must be some agency for deciding when the states are stepping outside of their province and conflicting with the national constitution, which within its limited field must be supreme. Notwithstanding the fact that state is prior to national sovereignty, it is obvious that the latter, because it is more general, must be the judge of disputed cases of jurisdiction, or otherwise it would have no sphere of supremacy at all It follows that the federal courts must have the power of passing on the conformity of state laws to the national constitution.

The same principle has been applied both within the several states and in the national government Soon after the government was established under the constitution, the federal Supreme Court laid claim to the power of passing on the constitutionality of congressional enactments, and after some dispute this claim was conceded. The situation is in fact somewhat anomalous, as under the Constitution Congress is expressly given the power to define the powers and procedure of the federal courts, but the place of the Supreme Court as the final interpreter of the Constitution has passed unchallenged throughout most of our history. The same principle is followed even more closely within the states. State constitutions have multiplied restrictions on the legislatures and legislative enactments and there had to be some power above the law-making body to see that it obeyed the law! This task also naturally fell to the state courts through their power to pass on the constitutionality of state laws.

Our theory of local government makes the courts the chief administrative organs

The courts, in addition to being thus the principal legislative agencies, have had thrown upon them the main burden of the execution of the laws and have performed a large part of the functions proper to the executive. The governmental relations which touch the everyday life of the people are those of the states Now the states have an elaborately organized administrative machinery, but it differs from perhaps every other such an organization in the world in that it has no authority to make it work. Offices are created, their incumbents elected or appointed, and duties laid down in detail. But if any official does not see fit to do his duty there is no one over him with power to make him do it, or to remove him if he does not, or to supervise and coördinate the system The state governor is the nominal head of the administration, but has very little real power.

The lawsuit has almost replaced administrative process in this country

All important state officials are independently elected, are similarly and equally servants of the people and are on a par with each other except in dignity. So also if any one does more than his duty, transgressing on the rights of a citizen, there is no authority to bring him to book, — except the courts! The party injured by any illegal act or inaction may call the offender before the bar of justice and thus bring him within the law. The lawsuit has in this country almost displaced administrative process. Many states even rely upon it to correct injustice in tax assessments, and provide no other means. The maladjustment of the situation is aggravated by the fact that the whole actual administration of the law is in the hands of local agencies, county and city officials. These functionaries are elected by and responsible to the local or district electorates and have no direct connection with the state government which makes and is nominally responsible for enforcing the laws they administer.

This slow, clumsy and costly procedure often worse than the evil itself

It is easy to see how this arrangement is the cause of many political difficulties of which we have heard much. Trial procedure is slow and clumsy and, though a possible remedy for nearly any wrong, it is often worse than the evil itself, whereas administrative procedure would afford redress without delay or appreciable cost. Many evils also cannot be repaired after they have happened, and must either be prevented or endured. Our courts have held, after some early hesitation on the part of the national Supreme Court, that they cannot give opinions except on actual cases brought before them in due form. Hence in case of doubt as to the legality of any conduct the only course is to go ahead and do it and see if anyone is able to collect damages or put you in jail. This is quite on a level with the famous recipe for distinguishing mushrooms from toadstools by eating them and observing whether you die as a result. Some states, such as Massachusetts, have constitutional provisions requiring the courts to hand down "advisory opinions" as to the constitutionality of proposed laws so that the work of the legislature might not be immediately nullified. But inasmuch as the courts have refused to be bound by their pronouncements, these opinions are not particularly significant. A statute passed in Michigan in 1921 to require the courts to deliver and abide by decrees as to the constitutionality of proposed legislative acts, was itself, ironically enough, held to be unconstitutional.

Development of the injunction and the mandamus to their abuse

To get around this intolerable state of affairs we have appealed again to the courts, developing the *injunction* and the *mandamus*, until "government by injunction" has become almost a description as well as a protest. But a civilized state cannot get along without government, and if authority is denied the individuals in a position to exercise it with expedition and discretion it will appear somewhere else.

It is perhaps impossible to explain the extraordinary willingness of the American people to trust the courts, in contrast with their extreme reluctance to grant effective authority to any other form of governmental agency. The result is in theory government by law, law made for the most part by the people themselves in constitutional conventions, and in fact a government by *lawyers*, with many of the evils of complete absence of government. In theory almost primary democracy, it is in large measure an oligarchy, an aristocracy of the robe. Only the extraordinary law-abiding character of the people and the temperateness of the legal profession as a class have made such a system workable at all, and it is rapidly becoming entirely unworkable The recent growing clamor against the courts is mainly due to their having been saddled with the proper functions of the legislative and executive branches of government. Such a government is conservative to the point of being hidebound, and the system has increased the difficulty of adapting a government working under a hierarchy of written constitutions to the rapidly changing conditions of the last half-century.

Effect of the partnership between party machines and business interests

In the "Middle Period" of American history the individualistic element of the population, especially strong in the newer West, came into control of the government, beginning with Jackson's administration.

It was strongly opposed to any positive or aggressive action by the government and intensely local in feeling. During this time it attempted to make the government more democratic by developing political party organization under the direct control of the people. The aim of its leaders was not so much to use the government for any purposes of their own as to prevent men with any ulterior designs from getting hold of it. It was the old dread of power which has always characterized us nationally, working to guard against any effective governmental action of any sort being carried through.

The Civil War gave an enormous impetus to the growth of national spirit in the country, strengthened the Union and made men accustomed and friendly to the exercise of power by the central government. Beginning with the advent to power of the Republican party, a kind of economic nationalism began to replace the localism of our earlier history. The government came to be used in a positive way to further the interests of the people, especially to stimulate business and promote economic development The method of procedure, however, was neither very constructive from a long-run point of view, nor essentially democratic, and in the end was bound to lead to trouble. The policy adopted was a sort of mutual exchange of favors among different classes in the population. The farmers of the West were given free land under the Homestead Law, while the manufacturing classes received the benefit of ever higher protective duties on their products. Enormous grants of land encouraged railroad building, and corporations generally were given such privileges as they wanted. Farmers were also made to believe that they were profited by the "home market" created for their produce by the artificial stimulation of home manufactures.

In the meantime, political party organization, which was well adapted to this system and flourished under it, got quite out of popular control. Intended originally to democratize the government, it came to be one of the main bulwarks of the special "interests" against the assertion of the popular will, and in recent years the process has had to be reversed, the authority of government being called upon to democratize party organization. Particularly under the leadership of Mr. Roosevelt, the public began to wake up to the alliance between the professional politicians who controlled the "machines" and business men who profited by special privileges within the gift of the governmental agencies. A demand for the purification of politics and the reform of the economic system has been the dominant feature of our political life in the twentieth century.

Lessons the cities have taught, and the spread of the reconstruction movement

The city is a miniature state and is the great experimental laboratory of politics. The government of American cities has had the same historic character as American government in general, but with slight modifications. It has shown the same distrust of executive power and reliance on the more "democratic" legislative council, and the same failure of the latter, followed by limitations on its functions and then by deterioration of personnel. Probably inefficiency and corruption have been worse in the cities than elsewhere in our political system. In this respect it is especially hopeful for democracy that it is the cities which are showing the larger units the way to better things.

To begin with, the greatest deficiency in all our governments is the weakness of the executive. For a long time the cities have shown a gradual but steady trend toward remedying this defect by restoring the dignity of the office of mayor and giving him real power. New York City is a good illustration of this movement. Though hampered, like other cities, by the political domination of the state government, New York has come to have a responsible executive at the head of a fairly well organized administration.

A devastating flood that gave us an object lesson in political methods

In September, 1900, the city of Galveston, Texas, was largely destroyed by a hurricane which carried the waters of the Gulf of Mexico over the place. In the crisis, the city government which was of the usual irresponsible American type, broke down completely. A group of the business men of the city, appealing to the state legislature, got the existing government summarily set aside and the affairs of the city placed in the hands of a committee of five, to be called "commissioners", and given absolute power, legislative and administrative. The achievements of the city under the new form of organization were so remarkable that not only did it have the system made permanent, but very soon other cities began to imitate the plan. This was the origin of *commission government*, which scores of cities, large and small, have since adopted and which has demonstrated great superiority over the old cumbersome methods. Many cities have adopted it in the improved form originated by Des Moines, which adds the initiative, referendum and recall to bring it more under popular control.

The small commission proving so much more efficient than the divided responsibility — or irresponsibility — of a mayor and one or two elected chambers, it was soon suggested that the idea be carried farther. The most modern type of city organization is therefore the "commission manager" form. In the old commission government, the commissioners divide the work, each taking the headship of one of the departments into which the business is organized. In his own field each is virtually supreme, both as legislator and executive, though the body meets for consultation. Often the men to whom departments fall are not especially fitted to deal with their problems.

The newer idea is to separate the legislative and executive functions and in the case of the latter to carry the process of concentration still farther. A popularly elected commission determines as a deliberative assembly the policies of the government. These are carried into effect by a single executive in whom all authority is concentrated. He is employed by the commission, need not be a resident of the city when chosen, is given an adequate salary and is chosen on the basis of expert qualifications for the work in hand. He is a municipal engineer, entirely inaccessible to political influence and interested only in getting his work done in the most effective way. His authority is supreme while he holds office, and his tenure is at the will of the commission which appoints him. Under this system many cities have made progress and achieved results which at the beginning of the century would have been thought entirely impossible. Dayton, Ohio, in particular, has become a Mecca for pilgrims interested in governmental efficiency.

The changing idea of democracy

From cities the movement has already been spreading to the states, while in the national government the growth of non-political administrative agencies goes steadily forward. The people are learning that a host of uncoördinated elected officials owing neither thanks nor duty to anyone but the voters, moreover often unknown to each other and with no unifying bond except allegiance to the same party name, form no guarantee of responsiveness to the popular will On the contrary, this is just what the purveyors of political privilege desire. It is easy to hide behind a divided responsibility, which really becomes irresponsibility. Such a system could not run at all without some external and unofficial organization, which is supplied by the party machines and their bosses. Inefficient at best, what effectiveness it has is mostly in the line of doing the will of self-appointed "leaders" who live on the spoils of office and the fruits of the collusion between politics and big business.

Not absence of government, but social efficiency and popular control needed

Nor is the recourse of "turning the rascals out", that is, putting the other party into power, any guarantee of improvement. It only means turning another set of "rascals" in, for under such a system any party with a fair chance of carrying an election is bound to be dominated by the same ideals of plunder. Between the parties there is some competition in promises, but very little in fulfilment. Even promises are dangerous, and the parties largely content themselves with stimulating blind loyalty to the party name, throwing mud at their opponents, appealing to fictitious or dead issues and promising "swag" to persons in positions of influence. Moreover, it is an oft-demonstrated fact that when any inroad on the fundamentals of the system is threatened the leaders of both parties coöperate secretly but loyally in throwing dust in the eyes of the public and opposing real reform.

However, the old game is becoming played out. The voice of the beguiled and plundered public is making itself heard. We are gaining new ideas of the possibilities of government in constructive work in advancing the welfare of the people, and we are learning the fundamentals of organization. The first principle is concentration of responsibility. This means fewer elective and more appointive officials and real authority in the hands of the head of the administration. The organization of business corporations points the way, and the example is beginning to be heeded. The "short ballot", reducing the number of independently elected officials, is gaining in favor. In addition to the movement toward businesslike government in the cities, states also are simplifying their administrative organizations, combining departments and bureaus to concentrate responsibility and unify governmental policy. The most outstanding example to date of progress of this kind is the great administrative reconstruction adopted by the state of Illinois in 1917. Even this did not change the status of any of the "cabinet" officers, which could only be done by constitutional revision. The new state constitution drafted after two years of bickering also failed to make any of these fundamental changes and still was voted down at the polls in the fall of 1922, sharing the fate of the New York state constitutional draft of 1915, which did contain notable short ballot provisions. The popular prejudice for election, as against appointment of administrative officers, as being the "democratic" method, is still very strong. The progress will for a long time be slow, but it continues to make real headway.

The growth of the non-political commission in national affairs

We have already observed that the national government was in the beginning far more effectively organized than those of the states. Indeed it is notable for concentration of executive power. It has been said that the President of the United States rules without reigning, in contrast with the heads of the other two great

democratic nations, England and France, in the former the king reigns but does not rule, while in the latter the President neither rules nor reigns The American system is open to criticism rather on the very different ground that the chief executive, being independently elected for a fixed term, is unresponsive to democratic control. In England and France the real as contrasted with the titular head of the government is a prime minister, chosen by the legislature and constantly responsible to it, holding office only so long as his policies command a majority Another weakness of the American plan was the "spoils system", the use of appointive offices as a means of rewarding party workers, but this has been largely corrected by the development of competitive examinations and indefinite tenure of their positions for civil service employees But this method is not applicable to the higher and more responsible officials.

The necessity and inevitability of growth of administrative government

Yet the new functions constantly being added to the duties of the national government have in no case been delegated to popularly elected officials, and the President and members of Congress continue to be the only federal officers chosen in this way. Instead, a new method, the permanent, non-partisan commission, has been developed. The change from legislative-judicial to administrative government has naturally gone forward most conspicuously in the field of public regulation of industry and commerce. The control of transportation affords one of the earliest and most instructive examples. After the Civil War came a period in which the public attention was largely occupied with abuses on the railways, in the way of overcharges, inadequate service and especially discrimination in service and charges. For a time both Congress and the various state legislatures attempted to deal with the problem by the old-fashioned method of passing laws to be enforced by the courts through action for damages or criminal prosecution. The failure of this method was so manifest that Congress was finally moved to pass the Interstate Commerce Commission Act of 1887 Tradition was so strong that the new commission was given little power, and that little was soon almost nullified by the courts, which assumed the power to review its decisions as to matters of fact as well as of law. The commission kept quietly at work, however, collecting and publishing dependable information, and by its decisions at least pointing out evils and their remedies even when the courts set aside the decision itself Thus the foundation was laid for more adequate legislation and increased power. Under the Mann Act of 1903, the Elkins Act of 1906 and subsequent amendments to the original law of 1887, the commission received the power which it needed and the emasculation of its orders by the courts was stopped. The Esch-Cummins Act of 1920, under which the railroads were returned to the owners after the period of government operation necessitated by the Great War has placed virtually complete authority over every phase of interstate commerce in the hands of this permanent, non-partisan board of experts

In the meantime, the same principle has been applied in other fields. The Federal Trade Commission established in 1914 represents a frank attempt to extend the principle of the Interstate Commerce Commission to the regulation of all interstate business. The Federal Reserve Board, created a year earlier, is an application of the same theory to the control of banking and the prevention of panics The experience of the war period, when the national emergency forced an enormous extension of governmental control under hastily improvised machinery, led to a reaction toward individualism, but it seems clear that the conditions of modern life make inevitable an extension of public regulation and governmental supervision, and the acceptance of improved methods for securing efficiency, impartiality and responsiveness to popular will becomes all the more important In the circumstances the rapid growth of administrative government appears necessary and inevitable.

Demands of modern democracy: executive responsibility and popular control

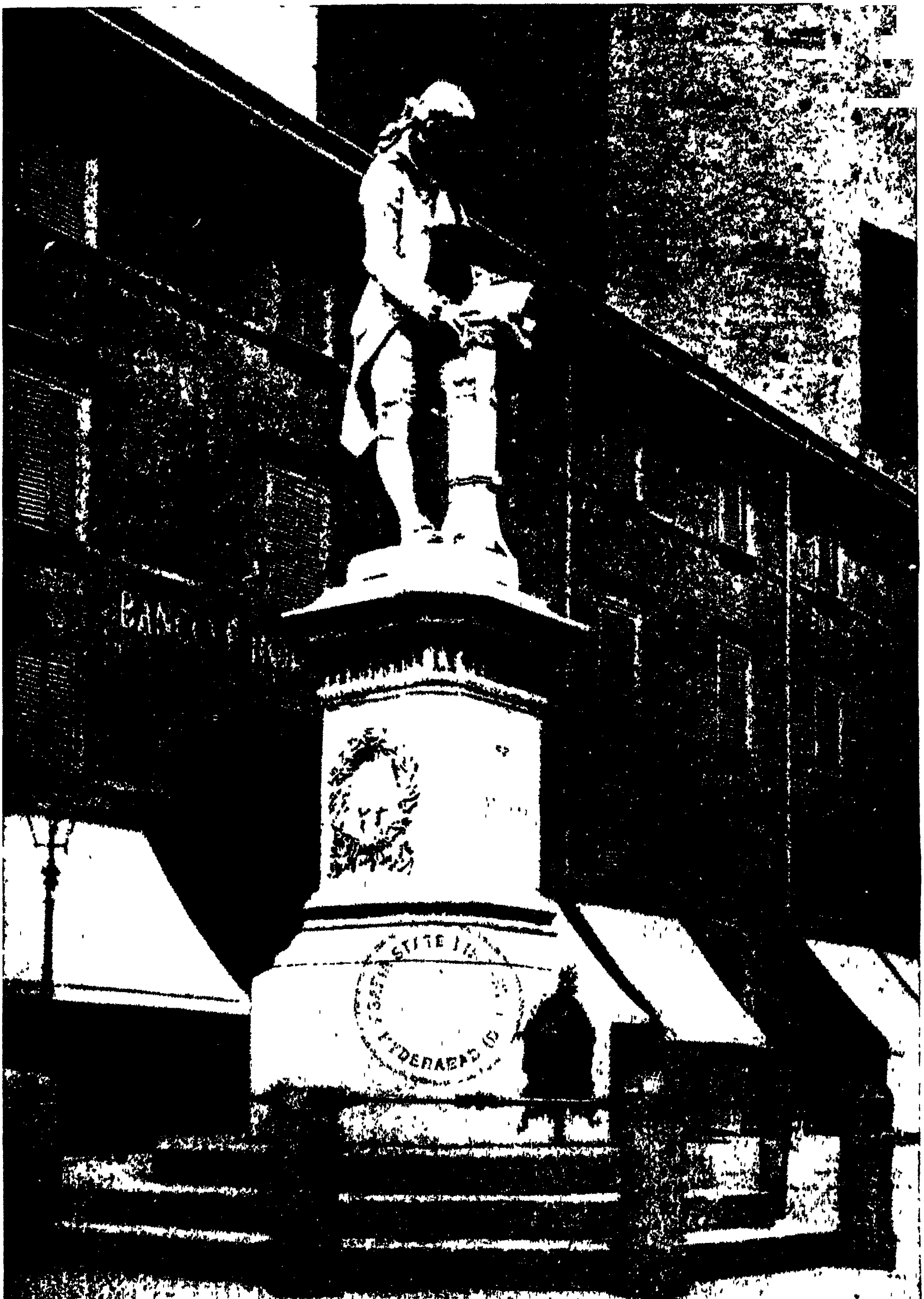
The main historic defect in our American governments has been the weakness of the executive The short-ballot and the development of the administrative commission are steps toward remedying this fault Another requisite is the executive budget When legislators are allowed to introduce appropriation bills, log-rolling is inevitable, as the notorious "pork-barrel" testified. Congressmen have their interest centered on local desires, and there is a tendency for a locality to estimate the services of a representative in terms of what he gets for them at the cost of the nation. The result is the "pie-counter"; public money is squandered to repair the political fences of members. Executive departments cannot be efficient or economical unless appropriations for their work are limited by their own demands.

In the United States it is not uncommon for expensive buildings and equipment to be forced upon a branch of governmental service against its wishes because these make a showing in somebody's district, while perhaps at the same time more important requirements of a less conspicuous kind are denied.

Many states have adopted a budget system of finance, in which the executive branch submits estimates of expenditures and suggests appropriate sources of revenue to the legislature, which can cut but not increase the allowance for any purpose. In our national government a step was taken toward more intelligent control of finance with the establishment of the Budget Bureau. President Taft's "Economy and Efficiency Commission" recommended budgetary finance, and during President Wilson's administration a bill passed Congress to that end, but was vetoed on account of technical defects. The law as passed after President Harding's election provides for a Budget Bureau in the Treasury Department, with a director appointed by the president for an indefinite term. The act directs the bureau to prepare an annual report giving an estimate of necessary expenditures of the government for the ensuing fiscal year, together with an estimate of the revenues, a report of the actual receipts and expenditures of the preceding year, and a similar report on the year in progress. Congress is placed under no compulsion to be guided by the recommendations in making its appropriations. But still, the first budget, submitted in 1921, represented a vast improvement over the hodge-podge finance by a multitude of separate committees which had been the rule, and Congress is placed under considerable pressure to conform, or show good reasons for not doing so.

All these measures to increase the power of the executive do not mean, as we wish to emphasize in conclusion, that the real importance of the legislature is to be reduced. It signifies merely that we are learning the proper functions of the legislature and of the executive, and are separating them. Ultimate determination of policy must rest with the legislature, and all details of carrying policies into effect with the executive. The function of the legislature is that of control, and is to be exercised especially through the power to refuse or restrict appropriations. The legislature also must have its hands freed to perform its own special task.

With this increase in the power and discretion of officials must undoubtedly be coupled an increased measure of direct popular control. The legislature will naturally have a veto power over every proposal of the executive, through merely failing to adopt it, and the executive will undoubtedly keep his veto over acts of the legislature. Probably both the legislature and executive should be given the power to "refer" a measure to popular vote if advocated by it and rejected or vetoed by the other branch. Perhaps our fixed terms of office might be safeguarded by a popular recall, as has been done in some states already It is along such lines, we believe, — the concentration of responsibility and increase of popular control, — that democracy will move forward and upward to the realization of possibilities greater than its present development has shown it to possess.



STATUE OF LUIGI GALVANI ERECTED IN BOLOGNA, HIS NATIVE CITY, IN 1879

CHEMISTS AND PHYSICISTS IV

LUIGI GALVANI—THE DISCOVERER OF ANIMAL MAGNETISM
JOSEPH LOUIS GAY-LUSSAC—DISCOVERER OF THE "LAW OF VOLUMES"
JOSIAH WILLARD GIBBS—THE FOUNDER OF CHEMICAL ENERGETICS
WILLIAM GILBERT—THE GREATEST SCIENTIST OF ELIZABETHAN TIMES
OTTO VON GUERICKE—THE DISCOVERER OF THE AIR-PUMP
HERMANN LUDWIG VON HELMHOLTZ—EXPLORER OF THE EYE AND EAR
JEAN BAPTISTE VAN HELMONT—HALF SCIENTIST, HALF CHARLATAN?
JOSEPH HENRY—A GREAT EXPERIMENTER IN ELECTRICITY
HEINRICH RUDOLF HERTZ—THE DISCOVERER OF ELECTRIC WAVES
AUGUST WILHELM VON HOFMANN—EXTRACTOR OF WEALTH FROM WASTE

LUIGI GALVANI
The Discoverer of Animal Magnetism

LUIGI GALVANI was born at Bologna, Italy, on September 9, 1737. In his early youth he devoted himself to the study of theology, with the intention of becoming a monk. With the greatest difficulty his father prevented him from entering the monastery by pointing out to him that the work of a doctor was an even more noble way of sacrificing one's self to the cause of suffering humanity. He threw himself into the study of medicine with the same intense energy with which he had taken up theology, and in early manhood became one of the most brilliant surgeons of his time. By a treatise on the formation of bones he won, in 1762, the professorship of anatomy in the university of his native town.

Twenty-four years passed before the merest hazard led him to the discovery of galvanism. His wife was attacked by a disease of the chest, and to maintain her strength she was fed on a broth of frogs' legs which Galvani always prepared with his own hands. One morning he had placed on his laboratory table, close to an electrical machine, some dead skinned frogs, and a fine knife that he used in his anatomical researches rested on one of the little creatures. He left the room without noticing anything, but his wife entered, and was surprised to see the limbs of one of the frogs moving in a strange, convulsive manner. Instead of being frightened, she tried to find out the cause of this apparent miraculous return to life of a dead frog. With great sagacity she traced it to the current produced by the electrical machine. She ran and told her husband, and he at once verified her brilliant idea. He laid the point of the knife on the nerves of one frog after another, while the electrical machine was not working, and the curious contraction of the muscles of the dead creatures did not occur. But as soon as a current of electricity was generated in the machine the current seemed to pass through the surgical knife and affect the nerves of the dead frogs.

Galvani wondered if a discharge of lightning would produce the same effect on the legs of a dead frog. Waiting till there was a feeling of thunder in the air, he ran a copper skewer through the frog's legs and suspended them to an iron railing on the balcony of his house. As soon as the copper touched the iron, the strange convulsive twitchings of the tiny dead limbs again recurred. Much to his surprise, Galvani discovered that the extraordinary effect could be produced in any weather and at any time of the day. As soon as the copper skewer was fixed in the iron railings the frog's legs seemed to come to life.

He arrived at the conclusion that all animals were endowed with a particular electricity which was secreted by the brain and distributed by the nervous system to the body, where the muscles acted as reservoirs of the strange force. He was quite wrong in his theory of the matter. The electricity did not reside in the animal tissue, but was produced by the contact of the copper skewer and the iron railing.

The famous anatomist merely created a primitive kind of electric battery out of copper and iron and moist animal tissue. But though his ideas were incorrect, his experiments opened up a large, new and important field in electrical science. The only way known to his contemporaries of producing an electric current was by friction, and it was a friction machine that the professor used in his laboratory.

But his experiment with a frog's leg, a copper skewer and an iron railing showed that electricity could be generated with ease and abundance through the chemical reaction of various forms of matter. Thus a new source of energy was discovered;

LUIGI GALVANI

and we are not yet able to tell fully what effect it may have on the destinies of the human race.

Galvani lost his professorship at Bologna when Napoleon invaded Italy. He was asked to swear allegiance to the new Cisalpine Republic, and he would not do so. So great was his fame that a special edict was published by the government restoring him to his position without asking him to take an oath, but the edict appeared too late. The death of his beloved wife, and the poverty and trouble into which he fell, sapped his vitality, and he died in his native town, on December 4, 1798, a broken-hearted man.

JOSEPH LOUIS GAY-LUSSAC

Discoverer of the "Law of Volumes"

JOSEPH LOUIS GAY-LUSSAC, one of the master-builders of modern science, was born on December 6, 1778, in the little town of Saint-Léonard-le-Noblat, in Limousin, France. His father was a judge, and but for the great Revolution the son would no doubt have been in turn a well-to-do legal dignitary. But when the French people rose against their king the provincial judge was thrown into the prison into which he had sent many men, and in the days of the "Terror" an order was made for him to be brought to Paris to be tried and guillotined. The fact that he had been an officer of the crown was sufficient to condemn him. But Joseph, then but a brilliant boy of fifteen, so worked upon the good feelings of the governor of the jail that the judge, who had in the days of his power made himself respected by his kindness, was allowed to remain in the prison of the little town, forgotten by the Terrorists of Paris.

He was set free at last; and though he had lost his position and his wealth he managed to send his son to school at Paris in 1795, and after the school was broken up young Gay-Lussac entered the famous Polytechnic school. To diminish the sacrifice his father had to make to get money for his education, the lad worked at night on his own studies, and spent all his leisure hours in the daytime in giving lessons to younger boys. In this way he managed to save his impoverished family some expense, so that sufficient money remained for his brother to study for a medical career. Naturally, Joseph had to work very hard, and there was some danger of his health giving way through want of rest and sleep. On the other hand, the difficulties of his position gave him an impetus to study that few other boys possessed, and in three years he had become an excellent engineer, with a passion for chemistry. He left the school with the career of a bridge-builder open to him, but he had happily attracted the notice of the leading chemist of the age, Berthollet, who offered him a position in his laboratory.

Gay-Lussac at once showed a remarkable talent for chemistry, and Berthollet, glad to find that the lonely, hard-working young man had more knowledge and skill than even he had fancied, obtained for him the position of assistant professor in the Polytechnic. In a few months the young man had distinguished himself by his discoveries and by his gift for teaching others. He took up the study of the law of gases, and showed that the volume of a gas increases at an ascertained and definite rate with the rise in temperature

His work on gases attracted the notice of other French men of science, and on April 2, 1804, they intrusted him with a very exciting and adventurous piece of research. Some Russian balloonists had taken observations high in the air that seemed to show that the influence of the earth's magnetism rapidly diminished at a great height above the ground. Gay-Lussac and another young man were sent up in a balloon, provided with the necessary instruments for studying this curious problem. They ascended to a height of 13,000 feet, and found that the magnetic needle there behaved exactly as it did on the surface of the earth. But Gay-Lussac was now carried away by the love of scientific aerial adventure.

He set out alone on September 16, 1804, on another balloon voyage. He rose over 23,000 feet, and though his breathing at this height was somewhat troubled he was far from feeling any disagreeable sickness. But he found the air so dry that it acted on his throat, and made the eating of the bread he had brought up with him a rather painful operation. No one before him had reached so great a height, and no later explorer of the air has been able to mount as high without great bodily trouble. The ease with which he made his record is still a matter of wonder. He collected some air at his extraordinary elevation, and on analyzing it after his descent he found it was composed in the same manner as that collected at the surface of the earth. His great discovery was in regard to the amount of heat in the air. For he found that the temperature diminished rapidly and with apparent regularity the higher he ascended. It is only lately that his law of the diminution of temperature above the earth has been checked and extended by means of unmanned balloons fitted with self-registering thermometers.

Returning to the study of gases, Gay-Lussac became one of the most famous of the master-builders of chemical science by an apparently simple study of the way in which oxygen and nitrogen combined together. It was related to the problem of weighing the atoms of compound substances; and when Dalton's theory was altered and simplified by the Italian chemist Avogadro, the discovery of Gay-Lussac's law of volumes became of extreme

JOSEPH LOUIS GAY-LUSSAC

importance. It is only within the last forty years or so that the true meaning of the facts established by Gay-Lussac and the interpretation given by Avogadro have been generally recognized; and much of the modern advance in chemistry has been due to that recognition.

In 1809 Gay-Lussac was made professor of chemistry at the Polytechnic. In the course of a long and happy life he further distinguished himself by discovering iodine and cyanogen and prussic acid, and he was generally recognized as one of the greatest of scientific authorities for many years before his death, on May 9, 1850.

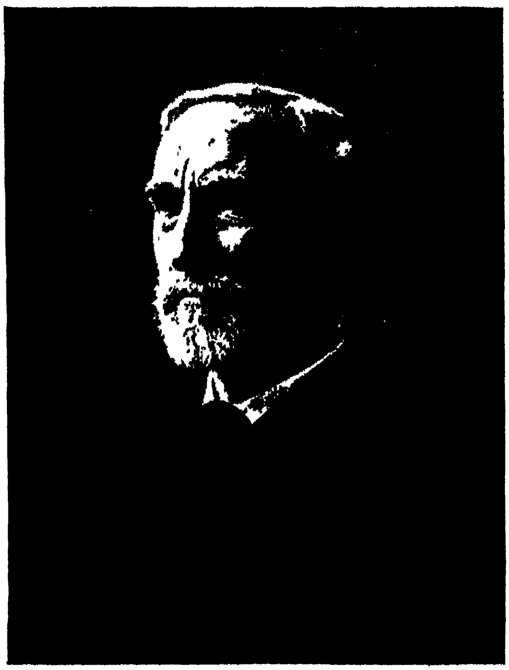
JOSIAH WILLARD GIBBS
The Founder of Chemical Energetics

WILLARD GIBBS was the son of an American philologist (1790–1861), professor of sacred literature at Yale Divinity School, and he was born in New Haven, February 11, 1839. His father was a graduate of Yale, but his grandfather, great-grandfather and great-great-grandfather were Harvard graduates, and he was the fifth of the name. He himself was graduated at Yale, after a brilliant course, in 1858 (M.A 1861; Ph.D. 1863); and after five years of special graduate work was appointed tutor in Latin and natural philosophy. After three years of this rather uncongenial work for a shy and scholarly recluse, he went abroad to continue his studies in mathematical physics in Paris, Berlin and Heidelberg. Most of all his teachers was he influenced by Clausius, one of the founders of the science of dynamics, and "by extending the fundamental laws of heat and mechanical energy discovered by Sadi Carnot and Clausius to the most varied departments of physics and chemistry, Gibbs made his chief contributions to human knowledge. Clausius's conception of entropy was by him raised to the rank of one of the most important of physical properties" Two years after his return to America, in 1871, Gibbs was appointed professor of mathematical physics at Yale, a post without salary for the first ten years of his occupancy and a small one only after the newly started Johns Hopkins University made him an offer. He still held the position when he died in 1903, thirty-two years later.

It was in 1873 that Gibbs published his first paper — a discussion of the methods for the geometrical representation of the thermodynamical properties of bodies. "He showed that by choosing volume, energy and entropy as the three physical properties of a body to be represented by rectangular coördinates, a geometrical surface is formed which gives a complete graphical representation of all the relations between volume, temperature, pressure, energy and entropy for all states of a body, whether single or a mixture of different states." This was a great advance from the common two-dimensions diagram, giving volume and pressure, for instance, but which cannot show the effects of changes in other physical properties — for example, temperature. The use of geometrical representations in place of confusing tables of figures or incomprehensible algebraic formulas has been of great advantage in the development of the science of physical chemistry, and many of them originated with Gibbs. His "thermodynamical surface", as it is called, attracted Clerk Maxwell's attention, who gave considerable attention to it in his "Theory of Heat" and who made a model in plaster of Paris which he sent to America, of such a surface for water in its three states: solid, fluid and gas. But Gibbs "did not think in mathematical formulas like Maxwell nor in mechanical models like Kelvin, but seemed to have some peculiar method of his own for conceiving complex relations between quantities". As Edwin E. Slosson says of him in "Leading American Men of Science": "Although he received little support from the college, he inherited a modest competence, sufficient to provide for his quiet tastes and keep him from uncongenial occupations. For his research he required no large and expensive laboratory. The only apparatus he needed was pencil and paper, and a small upper room in the Sloane Physical Laboratory was his workshop. Here until late at night he continued year after year his solitary search for truth for its own sake, without any of those external stimuli such as the hope of fame or fortune or the pressure of necessity which most men need to spur them to such arduous exertion."

It was in 1876 and 1878 Gibbs published his masterpiece, "On the Equilibrium of Heterogeneous Substances" in two parts, in the *Transactions* of the Connecticut Academy of Arts and Sciences, where for a dozen years it lay buried. Mr. Slosson says that to this paper "may be accurately applied the much abused term 'an epoch-making work' for it laid the foundation of the new science of physical chemis-

try. It was a triumph of creative intellect rarely equaled in the history of science for originality, completeness and vigor of demonstration. He laid down laws for phenomena that had not then been observed, and gave in advance solutions to problems that had never been formulated." The paper was translated into German by W. Ostwald in 1892, and into French by H. Le Chatelier in 1899, for the purpose of promoting the science of physical chemistry of which they were teachers and, even after the lapse of those long years, Ostwald speaks of the remarkable "wealth of results which it contains or to which it points the way, only a small part (of which) has up to the present time been made fruitful"; and Le Chatelier accords Gibbs "the honor of having fused the two sciences into one, chemical mechanics, of having constituted a completely defined body of principles to which additions may be made in the future, but from which the progress of the science can take nothing away". The verdict of Sir Joseph Larmor ("Encyclopædia Britannica", article "Energetics") is that this "monumental memoir made a clean sweep of the subject, and workers in the modern experimental science of physical chemistry have returned to it again and again to find their empirical principles forecasted in the light of pure theory, and to derive fresh inspiration for new departures". The reason for the neglect of the paper by American chemists, aside from the little accessible medium of publication, was that at the time there were few in this country sufficiently familiar with advanced mathematics to understand and use Gibbs's work. Larmor calls it "magnificent, but complex and difficult". The Dutch chemists were the first to profit by it, and they have, by the aid of "Gibbs's Phase Rule", the best known of the seven hundred odd formulas of the paper, and other laws of equilibrium, greatly added to our knowledge of such difficult matters as solutions, alloys and crystallizations. "Previously chemists had been absorbed in the recognition of chemical substances as individuals and in studying their transformations, but Gibbs discusses their behavior in the presence of each other. He shows under what conditions of temperature and pressure different substances and the same substances in different states, can exist together and what effect changes of these conditions will have upon the composition of such mixtures. . . Chemists find the most interesting and most common reactions are those that proceed only partially in one direction when they are checked by the opposite tendency and an equilibrium established. The study of the effect of the conditions, such as temperature, pressure and relative amount of



WILLARD GIBBS

the components, upon such an equilibrium is one of the most fruitful lines of investigation now being carried on." B. Roozeboom characterizes the subject of the paper as "the sociology of chemistry". The Copley medal of the Royal Society was awarded the author in 1901 as being "the first to apply the second law of thermodynamics to the exhaustive discussion of the relation between chemical, electrical and thermal energy and capacity for external work".

Gibbs's system of vector analysis, developed and used in teaching between

1881 and 1884, was the basis of a textbook published by his pupil, Dr. E. B. Wilson, in 1901. His papers on the electromagnetic theory of light as originated by Maxwell were published in the *American Journal of Science*, and his final work was "Elementary Principles of Statistical Mechanics" (1902). Professor Gibbs was never a strong man and he died, after a few days' illness, April 28, 1903.

Besides the Copley medal he had received the Rumford medal of the American Academy of Arts and Sciences; honorary degrees from Princeton, Williams, Erlangen and Christiania; honorary or corresponding membership in many of the principal academies and learned societies at home and abroad Dr. Fielding H. Garrison (*Pop. Sc. Mon.*, May, 1909, *et seq.*), in an interesting series of articles on "Josiah Willard Gibbs and his relation to Modern Science", says that "his mathematical theory of chemical equilibrium was far in advance of any experimental procedure known or contemplated at the time of its publication, and, although some of his predecessors, like James Thomson, Massieu, Horstmann, had come within sight of the new land and even skirted its shores, Gibbs, with the adventurous spirit of the true pioneer, not only conquered and explored it, but systematically surveyed it, living to see part of his territory occupied by a thriving band of workers, the physical chemists. Cayley, in his report on theoretical dynamics in 1857, expressed his conviction that the science of statics 'does not admit of much ulterior development'. The work of Gibbs has added to it the immense field of chemical equilibrium and wherever 'phases', 'heterogeneous systems', 'chemical and thermodynamic potentials', or 'critical states' are mentioned he has left his impress upon modern scientific thought."

By the gift of William A. Converse, the Chicago Section of the American Chemical Society has established a gold medal in honor of Willard Gibbs, to be awarded annually to leaders of chemical thought and experimentation. The first to receive this medal, in 1911, was Svante Arrhenius of Sweden.

WILLIAM GILBERT

The Greatest Scientist of Elizabethan Times

WILLIAM GILBERT, the father of the sciences of magnetism and electricity, was the son of a recorder of Colchester, England, at which town he was born on May 24, 1540. Little is known of his boyhood, but at eighteen he entered St. John's College, Cambridge, where he remained for seven years. At twenty-one he was elected a fellow of his college and examiner in mathematics. But a quiet life of study and teaching did not attract him. He had the Elizabethan passion for freedom and excitement of life, and, taking up the study of medicine as a means of existence, he won his doctor's degree in 1569, and then spent three years in foreign travel.

Returning to London in 1573, he soon worked up a good practice, became president of the College of Physicians, and both Queen Elizabeth and King James appointed him their doctor. But, in spite of his success in the study and practice of medicine, Gilbert regarded his calling as only a means to an end. It supplied him with the money he needed for other work. The social position he won brought him into contact with Sir Francis Drake, who was able to help him by studying the curious behavior of the compass when his ship was sailing through distant seas.

At the time when Gilbert took up the study of the mariner's compass, the subject was more involved in mystery than it had ever been. Columbus had noticed, when two hundred leagues from Europe, the variation of the needle from the true north. And so had Cabot. Later on Robert Norman discovered that the needle had a tendency to dip according to the latitude in which the ship was that carried it. But nobody divined the reason for this strange behavior of the compass. Some persons thought that the Pole star was an immense magnet that attracted the magnetic needle; others supposed there was an island or mountain of magnetic ore in the Arctic regions, towards which the needle pointed. It was said that when a ship approached this island

all the bolts and nails that held the timbers together flew out, and the vessel fell in pieces. Some ancient doctors used powdered magnets as a purge for melancholy, and even in Gilbert's lifetime poultices were made out of ground loadstones by Paracelsus.

It was Gilbert who rescued the study of the magnet from the atmosphere of wild superstition and placed it on a scientific basis. From the observations that his sailor friends made under his directions, he arrived at the grand fact that the behavior of the compass was to be explained on the theory that the earth itself was a great magnet. Then came the discovery by which he proved his theory. He placed a rod of iron pointing north and south, and hammered it so that it became magnetized by the influence of the earth's magnetism. After many experiments of this kind, he sufficiently verified his theory to publish it in 1600 in his famous work "De Magnete".

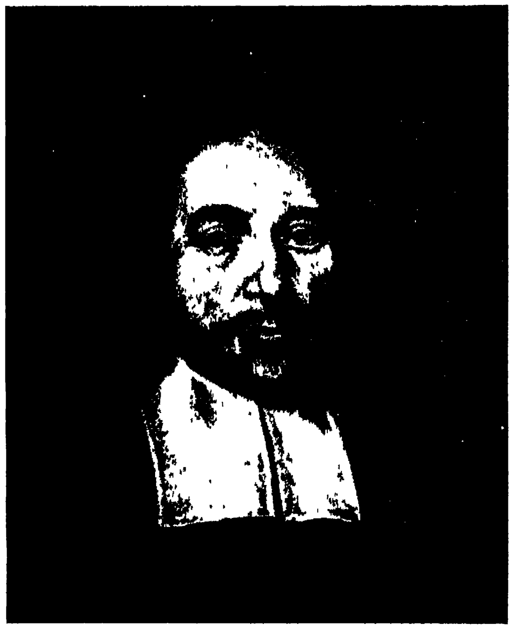
Besides solving the mystery of the magnet, this book contains a short digression on the properties of amber. The Greek word for amber is "elektron", and from it Gilbert derived his term for the strange property that amber possessed when it was rubbed—"electricitas". It had been known for more than two thousand years that if a piece of amber were rubbed on a woolen cloth it would attract small pieces of straw or woody fiber. At a much later time it was found that jet, when rubbed, possessed the same power of attraction. That was all that was known about electricity when Gilbert was led to study it in connection with his experiments on magnetism. He made a light needle of metal, pivoted like a compass on a pin, and with this rough electroscope he tested the electrical properties of other substances, and found that many things besides amber and jet could be so electrified by friction as to make his needle move when brought close to it. He was the father of electricity, but he left his child in its infancy.

For he died on November 30, 1603, a few years after making his first experiments. He also founded a society for the promotion of science, but this unfortunately broke up on his death.

OTTO VON GUERICKE

The Discoverer of the Air-pump

OTTO VON GUERICKE, the maker of the first pneumatic machine and of the first electric machine, was born at Magdeburg, in Germany, on October 20, 1602. He studied law at various German universities, learned mathematics in Holland, and visited France and England. On returning to Magdeburg, he was made senator and, later, burgomaster of his native town. His invention of the air-pump in 1650 was a shining event in the history of modern science. It enabled him to settle



OTTO VON GUERICKE

the vexed problem of the weight of the atmosphere, and show how completely wrong Aristotle had been in dogmatically deciding that air had no weight. With remarkable ingenuity Guericke made a metal globe, divided into two hemispheres that fitted exactly into each other. By means of his air-pump he emptied this globe of air and, in the presence of a large concourse of people, he invited anyone to pull it apart Twenty-five horses were necessary to accomplish this, yet Guericke showed that, by turning a little tap and admitting the air, the two hemispheres could be easily separated by a man.

In this striking manner he proved that the pressure of the atmosphere on a vacuum globe was such that twenty-five horses were required to overcome it

Guericke also used his air-pump to determine the actual weight of the gases of the atmosphere He did this by weighing a globe full of air, and then pumping the air out and weighing the exhausted globe Some of the townspeople were inclined to regard him as a magician. What particularly aroused their suspicion was a weather prophet that always appeared in a recess in the wall of his house whenever there was likely to be a storm The ingenious burgomaster had built a great barometer filled with water; on the surface of the water floated the figure of the automatic weather prophet. The top of the water-pipe was open so that the pressure of the atmosphere acted upon the water and drove it higher into the second part, and thus when a storm was approaching the floating figure rose into view.

Still more wonderful was the globe of sulphur that Guericke made by melting sulphur in a glass bowl and breaking the glass away He mounted the sulphur orb on an axis and whirled it round, rubbing it as it spun. The friction generated electricity, and electric fire was obtained, to the astonishment of all beholders. Guericke's chief discovery in electricity was that when a body was bathed in an electric atmosphere it became charged with an electricity opposite to that of the atmosphere. That is to say, he found that when a piece of paper was attracted to his charged globe of sulphur it was afterwards repelled from the globe. Not until it lost its first charge of electricity by touching some other body could it be attracted by the sulphur globe.

Simple as the burgomaster's experiments now seem, they opened the two roads in chemistry and electricity which led to these sciences becoming instruments of tremendous power in the hands of later investigators. When Guericke died, in 1686, Boyle had used his air-pump to discover the law of gases, and Stephen Gray was working towards the discovery of the electric current

HERMANN VON HELMHOLTZ

Explorer of the Eye and Ear

HERMANN LUDWIG FERDINAND VON HELMHOLTZ, one of the great men of the nineteenth century, and a supremely great physicist, was born on August 31, 1821, at Potsdam. His mother was a descendant of William Penn. His father, a schoolmaster, wished him to study languages and literature and follow in his footsteps; but while the boy was apparently studying Latin with his classmates he was really experimenting under the table with the problems of a telescope. Some of his father's spectacle-glasses and a small lens for use in teaching botany were employed by the lad in making an optical instrument. At seventeen Helmholtz wanted to devote his life to the study of physics, but as his father had only $750 a year on which to bring up a family of four children the lad had to be content with the career of a surgeon in the Prussian army; for a free scientific education was given to youths of promise at the University of Berlin, on condition that they became military surgeons.

At twenty-one Helmholtz distinguished himself by the discovery of nerve-cells in the ganglia This was the curious result of a severe illness He had an attack of typhus fever, and while he was being treated in the hospital his small weekly allowance for board was still paid to him With the money Helmholtz bought a microscope, and with this he discovered the nerve-cells. From 1842 to 1847 he lived at Berlin, having been relieved from his military duties by Humboldt, who quickly recognized his genius. While lecturing on anatomy, he took up the study of animal heat, and began the investigation which enabled him to help in laying the foundations of the great doctrine of the conservation of energy. He also worked out the speed with which a nervous impulse travels along the sensory nerves of man.

In 1851 he was lecturing on the glow of reflected light often seen in the eyes of cats and other animals. He wanted to show his class the nature of the glow, and

with this aim he invented an instrument for exploring the interior of the eye through the pupil. This was the ophthalmoscope, which has proved of great importance even in the study of certain brain and kidney diseases which can be clearly diagnosed from a view of the interior of the eye When a great eye-surgeon first saw the optic disc and blood-vessels of the living human eye, his face flushed with excitement as he said: "Helmholtz has opened up a new world for us! What is there left to discover?" By means of his instrument the young man of science was able not only to flood with light the obscure diseases and troubles of the eye, but to make contributions of the utmost importance on the problem of vision.

A year or two after his discovery of the interior of the living eye, he took up the study of hearing, and laid the basis of aural science By giving the first real account of the mechanism of the internal ear, he showed how the sensations of tone were formed. He also investigated in a masterly fashion the cause of the qualities of the human voice. His work on the eye and ear is done so splendidly that it must for generations remain an enduring monument to his genius.

His life was a calm and uneventful one; he worked in long, fierce outbursts of research, and then usually went to Switzerland for a rest In 1849 he was professor of physiology in Konigsberg, and in 1855 he occupied the same position at Bonn. Later on he went to Heidelberg, and in 1871 he was called to the chair of physics in Berlin. To this professorship was added, in 1887, the post of president of the Physiotechnical Institute at Charlottenberg, founded by one of his friends. He had now raised himself to the position of being the first physicist in Germany, and his fame extended throughout the civilized world. The latter part of his life was devoted almost entirely to the investigation of physical problems of an abstruse nature. In spite of the fact that he had never received a training in mathematics, he became one of the great mathematicians of the age. Early in life he played an important part in founding the law of the conservation of energy, working with Joule and Lord Kelvin on the subject. In electricity he took up the study of electrical observations and, by using the nerve from a frog's leg as a recording instrument, he found that electromagnetic induction was propagated at the velocity of 314,400 meters a second.

When Clerk Maxwell developed Faraday's ideas into the theory of electric waves propagated through the ether, Helmholtz set his favorite pupil, Heinrich Hertz, the problem of finding these mysterious waves. Hertz succeeded, and wireless telegraphy and telephony became possible. Hertz always said that the inspiration came from his master. Helmholtz visited the United States in 1893, and died in Berlin September 8, 1894.

JEAN BAPTISTE VAN HELMONT
Half Scientist, Half Charlatan

JEAN BAPTISTE VAN HELMONT, alchemist and doctor, was born at Brussels in 1577. Belonging to a noble family, he was fairly well off when he had finished his studies in the learning of his time But after reading Tauler and other mystical writers he decided to renounce all his property and devote himself to medicine so as to be able to help the very poor. He obtained his degree of doctor at Louvain in 1599, and the next ten years of his life were spent in traveling in Switzerland, Italy, France and England. An Italian quack he met on his travels inspired him with a passion for alchemy, and for the search after the philosopher's stone Van Helmont became entirely absorbed in these futile problems, and by marrying an heiress at Antwerp he obtained the funds he needed in his wild experiments. He settled at Vilvorde, near Brussels; and when a boy was born to him he received the name of Mercury, for the reason that Van Helmont believed he had succeeded in extracting gold from mercury on the day of his son's birth. The secret of prolonging human life was another problem which this alchemist pretended he had solved. Nevertheless, he died himself at sixty-seven, leaving his son to continue his researches.

Van Helmont, it is said, also saw his own soul in the form of a resplendent crystal, and in recompense for all his virtues a good spirit was attached to his person to help him in his work. By this means he was able to discover infallible remedies for all diseases; and one of his disciples says that so surprising were his cures that he narrowly escaped an accusation of witchcraft and devil-worship. As a matter of fact, Van Helmont's talent in medicine was very small; the enthusiasm he excited had its source in the ardent

JEAN BAPTISTE VAN HELMONT

conviction with which he propagated his doctrines rather than in the results obtained from the use of his remedies. There was certainly a good deal of superstition in the confidence that he inspired.

But if as a doctor he was of little worth, as a chemist he was a man of genius. No doubt there is much superstition also in his chemical work for, like the other alchemists of his age and in spite of his fine experimental researches, he held to many odd opinions and absurd fancies. But, in spite of all Van Helmont's failings as a man of science, there is one of his achievements which alone suffices to make his name immortal. He has to his credit the strangely delayed discovery of gas.

This discovery is one of the most memorable in the history of modern science. What is still more remarkable is the fact that Helmont recognized the existence of carbonic acid, the first gas he found, not by its striking effects, but by the force of reasoning He had observed that when coal burned away it left only an insignificant residue of cinders. From this he concluded that the rest of the coal had disappeared in a volatile form, which he called wild gas "This spirit that is contained in vessels, but that cannot be reduced to a visible body," said Van Helmont, "I called by a new name — gas." To Van Helmont are also attributed the invention of the water thermometer, the discovery of sulphuric acid, and other well-known chemical substances.

The philosophical doctrines of Van Helmont are a strange mixture of superstition and experimental science. Some of the ideas are very novel, and are animated by a lively feeling of rebellion against the authority of Aristotle and the schoolmen of the Middle Ages. He believed, however, that the ecstasy of the mystic gave a more direct vision of things as they were than did the experiments of the man of science.

JOSEPH HENRY

A Great Experimenter in Electricity

THIS distinguished physicist was born in Albany, N. Y., December 17, 1797. He attended a district school and later Albany Academy, and did some teaching, studying mathematics and physics meanwhile. To the Albany Institute he contributed occasional papers in 1824 and 1825 ("Chemical and Mechanical Effects of Steam," etc.), and in its *Transactions* he published a map of the state with especial reference to the newly inaugurated canal system, the result of a survey, in which he was assistant engineer, of a state road from the Hudson to Lake Erie. This work he had taken up to restore his health by outdoor occupation. Soon after the survey was finished he was appointed professor of mathematics in the Albany Academy. He now took up the experiments and investigations into the laws of

electricity, which had been rather neglected since the discoveries of Franklin, Volta and Galvani, experiments of a practical value which was to be demonstrated by others rather than himself. He developed the electromagnet, enormously increasing its power by passing more and more coils of silk-wound wire around the magnet. He was also the first to call attention to the difference between the quantity of electricity and its projectile force, a distinction at the base of all modern appliances of electricity. Henry's "quantity" magnets showed unprecedented lifting powers. In 1830 with a battery having a single plate of zinc of half a square foot of surface, he made a magnet lift 750 pounds, more than 35 times its own weight. Another (1831) lifted 2300, still another (1834) 3500 pounds.

In 1831 Henry installed an electric circuit several miles in length around a room in the Albany Academy. Through this was sent a current, which passed en route through the coils of an electromagnet. Between the poles of the latter was swung a permanent magnet in such a way that it rang a bell when the current was turned on. This was the earliest example of a true magnetic telegraph, and these experiments were continued by Professor Morse three years afterwards when devising the practical telegraph.

Henry's discovery of the method of production of magneto-electricity antedated Faraday, but, delaying to perfect it before announcing it, his publication of it was anticipated. Of this loss of priority he never complained, his attitude to other investigators always being most generous and disinterested. Others of his discoveries included the self-induction of an electric current, with special reference to the influence of a spiral conductor upon it, the precursors of later forms of relay and receiving magnets, and the oscillatory nature of the electrical discharge — for instance from a Leyden jar.

In 1832 Henry was called to the chair of natural philosophy at Princeton, but continued his electrical investigations, and made his researches into solar radiation and the heat of the sun's spots that laid the foundation of that branch of modern solar physics and started Secchi on his subsequent brilliant investigations

In 1846 Henry was elected secretary and director of the newly established Smithsonian Institution, and in 1852 he was appointed to the reorganized lighthouse board of which, from 1871, he was president. "He was the first to apply the telegraph to meteorological research, to have the atmospheric conditions daily indicated on a large map, to utilize the

Photo Harris & Ewing

JOSEPH HENRY

Statue in the Congressional Library at Washington.

generalizations and to embrace a continent under a single system." His experiments in acoustics resulted in giving us the best system of coast fog signals in the world. As Simon Newcomb said of him: "He was a born experimentalist, one who knew how to cross-examine nature. as an astute lawyer would cross-examine a witness and thus bring out her inmost secrets. Whether his questions pertained to the most familiar phenomena of everyday life or the most complex combinations in the laboratory, they are all marked by the qualities of the author's

mind — acuteness in research, a clear appreciation of the logic of science, and an enthusiasm for truth irrespective of its utilitarian results" For the last ten years of his life, Henry was elected president each year of the National Academy of Sciences and, from its organization in 1871, he was president also of the Philosophical Society of Washington. In that city he died on May 13, 1878

There is a fine statue of this prince of American physicists in the rotunda of the Library of Congress.

HEINRICH RUDOLF HERTZ
The Discoverer of Electric Waves

HEINRICH RUDOLF HERTZ, the discoverer of the electric waves, was born at Hamburg on February 22, 1857. After his school days were over he thought of becoming an engineer, and at twenty went to Munich to study for his profession. He soon found, however, that his talent for engineering would never be remarkable Instead of interesting himself in the practical details of his work, he was more concerned about the physical theories on which practical mechanics are based. In less than a year he gave up all thought of becoming an engineer, as it was now clear to him that physical science was something he could work at with joy.

He was resolved this time that he would make his mark, and make it quickly. He devoted the winter of 1877 to reading up great original treatises by the famous physicists of the past. At the same time he attended courses on experimental physics under most experienced teachers. The result was that soon after his arrival at Berlin University, in October, 1878, he attracted the attention of the leading experts, and was quickly allotted original research work One of the faculties of the university offered a prize for the best solution of a difficult problem in electricity. Hertz won the prize, and became the favorite pupil of Helmholtz. In his next piece of research, undertaken for his doctor's degree, he so surpassed all competitors that an uncommon distinction had to be made for him. From 1880 to 1883 he was assistant to Helmholtz, for whom he carried out some difficult researches in physical science. It was also in 1883 that he seriously began his study of Clerk Maxwell's electromagnetic theory, in which the existence of electric waves was assumed and their lengths calculated. Various attempts were being made to discover the actual existence of wireless electricity. The waves themselves had been studied in connection with currents sent along a wire, but nobody could substantiate Clerk Maxwell's ideas of free electric waves rippling through the mysterious ether.

Hertz made his famous discovery between 1885 and 1889, when he was professor of physics at the Karlsruhe Polytechnic. Clerk Maxwell had shown that if a conductor is electrically charged or discharged with sufficient suddenness, it must emit electrical waves into the ether, because the charge given to it will not settle down instantly but will surge to and fro for some time. These surgings produce waves in the ether.

If a wire is handy they will run along it, and may be discerned a long way off. If no wire exists, they will spread out like a sound from a bell or a light from a spark, and their intensity will diminish with the distance Clerk Maxwell and his followers were able to predict the rate at which these waves would travel It was known they would go slower in glass and water than in air; that they would curl round sharp edges and be reflected back, somewhat like a ray of light, when they struck against a conductor. It was known how to calculate the length of such waves, and even how to produce them of any length, from a foot to 1000 miles.

All this was known, but unverified, and Hertz supplied the verification. By means of a special radiator he created a series of waves of different lengths Then he put a special conductor in the path of the waves, and to his great surprise he found that the mysterious electromagnetic wave clearly manifested itself in a minute spark. His success was largely due to the fact that he employed an instrument that gave off waves of varying lengths, and picked up the waves by a

broken ring of metal which was a poor absorber, but a persistent vibrator. But, having discovered the waves, Hertz did not stop there. By laborious and difficult experiments he ascertained that the previously calculated lengths of the waves were thoroughly borne out by fact. His experiments in the measurement of electromagnetic waves in free space were his greatest achievement.

He worked out every detail of the theory splendidly, and turned what to most physicists would have been a confusing mass of troublesome facts into a harmonious system of laws. He especially showed that in their susceptibility to reflection, refraction and polarization the electric waves were in complete correspondence with the waves of light and heat. Hertz never regarded his discovery as of much practical importance To him it was merely a confirmation of an abstruse mathematical theory. A very modest man, with a beautifully kind nature, he did not trouble about any possible industrial application of his discovery. He had dropped all interest in that kind of question when he gave up his idea of becoming an engineer.

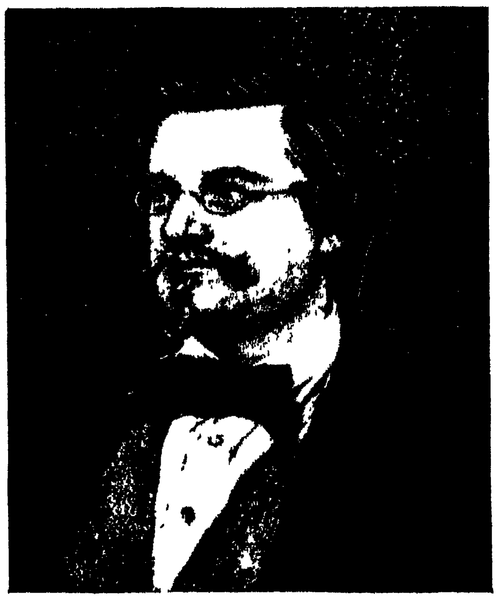
In 1889 he was appointed professor of physics at Bonn. Here he continued the study of electrical discharges through gases, a subject he had taken up under Helmholtz. He managed to get a mysterious ray of a visible kind out of the glass, but he overlooked the X-ray, which was actually streaming out of the vacuum tube during his experiments, and so Professor Röntgen had something left to discover later.

Hertz died, at thirty-seven, on January 1, 1894. His premature death counts among the great losses of science. He was surrounded from his birth with all the influences that go to make an accomplished man of science. He was strong both on the experimental and the mathematical side; and he did not go down to the grave till he had effected an achievement that will keep his name immortal as the founder of a new epoch in experimental physics, and the discoverer of a new force for the use of civilization.

AUGUST WILHELM VON HOFMANN

The Extractor of Wealth from Waste

AUGUST WILHELM VON HOFMANN, the father of all the great coal-tar industries, was born at Giessen, in Hesse, on April 8, 1818. Although Liebig had settled in his native town, and made it the most famous center of chemical science in Europe, Hofmann was not at first attracted to chemistry. He devoted himself to the study of law and philology, and he then took up mathematics and physics. Though he mixed with the active investigators in Liebig's laboratory he did not take any part in their work. But when he



AUGUST WILHELM VON HOFMANN

at last was attracted to the new science he rapidly distinguished himself, and became the most brilliant of Liebig's pupils. His first piece of research at Giessen, made in 1843, was an investigation of the organic substances contained in coal-gas, and he was the first man to find in coal-tar the now famous aniline that has become of the greatest importance in the manufacture of dyes.

Largely through the influence of the Prince Consort, Hofmann was induced to go to London in 1845, and take the direction of the newly established and much needed Royal College of Chemistry.

Hofmann, by his enthusiasm and energy, quickly gathered around him a band of young men many of whom afterwards became famous. Among them were Sir William Henry Perkin, Sir William Crookes, and Sir Frederick Abel. Most of them continued their master's researches on coal-tar, one of the results of which was that Perkin at the age of eighteen discovered his first mauve dye. Hofmann then hoped that the English people, with this proof of the practical value of chemical science before them, would encourage the new scientific industry. In a glowing speech he prophesied that England would soon be using her vast supply of coal-tar in supplying the world with dyes, and making the work of the indigo planters and madder cultivators useless.

But the subscribers to the Royal College of Science, that only needed a few thousand pounds a year to endow their country with industries bringing in annually many millions, began to withdraw their support, and manufacturers generally took not the slightest interest in applied science Yet Hofmann at this time, by his enthusiasm and energy and genius, had made the Chemical School famous throughout Europe. His warnings to British manufacturers passed unheeded. The power of money, he said, can do much, but capital, directed by the lights of science, can do much more. Those nations that neglect to call in the aid of science will find their prosperity diminish as neighboring countries become strengthened and invigorated under the general influence of science.

It especially hurt Hofmann that he found no industrial backing in England; and he came to the conclusion that Englishmen were dulled and stupefied by the wealth arising from the inventions of their forefathers. So, instead of fighting a losing battle in a foreign land, he returned to Germany in 1864, and the next year was appointed professor of chemistry and director of the laboratory in Berlin University. Almost from the moment of his departure the higher chemical industries decayed in England. The Chemical College, to which he had devoted nearly twenty of the best years of his life, was slowly starved to death, eventually being absorbed in the School of Mines, and the coal-tar manufactures, brought into existence by himself and his English pupils, were allowed to slip into the hands of Germany, to her enormous profit to the tune of millions of dollars a year.

Hofmann was not only a masterly organizer and a matchless teacher, but he exercised a greater and more direct influence upon industrial development than any other chemist. By reason of his early studies of languages he possessed a clear and striking power of expression, and he spoke English with great fluency. No man so capable as he could have been found for the work of training a great school of chemists. Sir William Perkin was merely a boy of fifteen when he came under his influence, and in three years he was a master-chemist, with a great discovery to his credit. Hofmann advised him to continue his research work instead of at once taking up the industrial application of the artificial dye he had found. It was a misfortune for England that the young chemist did not follow this good advice!

Hofmann himself devoted the latter part of his career to the study of amines and ammonium compounds. He was never a skilful manipulator, and after thinking out a problem, he preferred to set his pupils on the task of experimentation instead of doing the work himself. He thus gave his assistants splendid opportunities of distinguishing themselves; and it is no doubt due to his generous methods of direction that so many of his pupils made their mark in chemical history. He had the power of infecting young men with his own enthusiasm, and of impelling them to exercise their best powers.

Hofmann died in Berlin on May 5, 1892; and the German Chemical Society, of which he was the founder, erected a memorial to him in Hofmann House. It was opened in 1900 in the most striking manner with an account of the latest victory of German chemical enterprise — the manufacture of synthetical indigo.

THE VARIOUS CEREALS

The Gift of Ceres, the Mythological Goddess of Agriculture and the Harvest

ONE OF THE OLDEST FORMS OF HUMAN FOOD

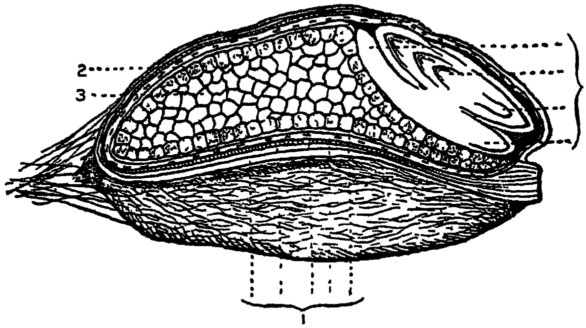
GRAINS or cereals are one of the oldest forms of human food and have been in constant use ever since man, developing wisdom and foresight, ceased from his wandering life and began to cultivate the soil. Cereals are so named from Ceres, the goddess of agriculture and of the harvest, who was conceived by the ancient Greeks and Romans as the cause of the mysterious evolution of life out of the seed. Mythology reveals that it was Ceres who first inspired mankind with an interest in property and the ownership of land, who created the feeling of patriotism and the maintenance of law and order. The introduction of civilization may thus be traced to grain production, since the custom of living in settled communities originated from the necessities of agriculture. Many of the ancient wars in history were waged in an effort to gain access to territory suitable for grain growing, since famine was a much dreaded menace owing to the difficulty of securing an adequate supply of this very important article of food.

The cereals are the farinaceous seeds of different species of the grass family. These plants pack starch, protein, oils and other elements needed for the growth of the young plant into the seed, which is the portion used for human food. The grains most commonly cultivated and used on this continent are wheat, oats, corn or maize, barley and buckwheat. How to convert these seeds into wholesome, palatable food was the task allotted to primitive woman, and she had to devise some method whereby the grain could be crushed, the husk removed and the meal portion separated Various devices were used for this purpose, and the first real grinding was done by means of two stones, a large one, slightly concave, which held the grain, and a smaller one which was rubbed back and forth, thus crushing it. The operation of these primitive mills was part of woman's daily household tasks, and is done even today in very much the same crude way in some parts of Africa and South America.

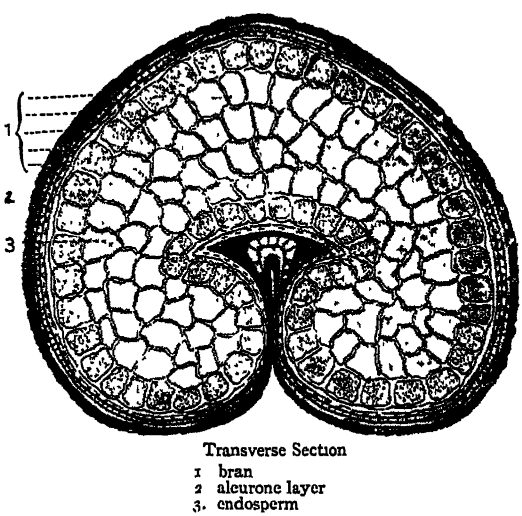
Wheat was no doubt the first cereal thus prepared for human use, and hence whole wheat bread was probably the first made since the entire grain was ground up into meal. Bread has long been called the "staff of life", possibly because, with the exception of milk, it was found to support life better than any other single food. The method of preparing bread in primitive times was very simple indeed, the whole meal being merely mixed with water and then baked on hot stones or in hot ashes, producing a hard cake or biscuit. Although unleavened bread was used in primitive times, the use of leaven is itself very ancient, dating back to the time when the Israelites were sojourning in Egypt. The first leavening agent was yeast, contained in a piece of dough reserved from the previous baking, although how it first became known is not revealed in historic records. It is a well-known fact that wild yeasts are present in the atmosphere, and so doubtless their leavening power was accidentally discovered by some primitive housewife unwittingly leaving the flour and water mixture exposed to the air and then afterwards baking it, thus producing a lightened loaf.

The admirable structure of a tiny grain of wheat

Wheat is probably the most extensively cultivated and the most universally used grain in America and it is also more widely milled, furnishing a larger number of products than any of the other cereals. While the various cereals differ somewhat in their chemical composition, most of them are similar in structure; hence a study of the formation and milling of wheat will make it easy to understand the production of flour from all of them.



Longitudinal Section



Transverse Section
1 bran
2 aleurone layer
3. endosperm
4 germ

DIAGRAM OF A GRAIN OF WHEAT

In order to have a clear understanding of the value in the diet of the different wheat products it is necessary to know what part of the kernel each contains. An examination of the structure of a kernel of wheat will serve to make further discussion clearer (see the diagram). Surrounding the grain of wheat is the husk or fibrous outer layer, but this is not used for human food since it is so very coarse and tough. Lying immediately under this outer coat is the bran, which is composed of several distinct layers and, with the aleurone layer, constitutes about 15 per cent of the entire grain.

Directly beneath the bran is found a single layer of large cells full of granular material which is rich in protein and phosphorus and which completely surrounds the flour or endosperm portion of the grain and is known as the "aleurone" layer. The whole central portion of the seed, or 83.5 per cent, is the endosperm or flour portion which furnishes food needed for the embryo plant when the seed germinates.

The endosperm consists of thousands of cells, the walls of which are cellulose material; while the contents consist of innumerable starch granules together with protein materials, chiefly glutenin and gliadin, which when kneaded with water form gluten, the tenacious elastic material so important in bread making. The germ or embryonic plant comprises 1.5 per cent of the grain and is rich in oils, mineral constituents and vitamins.

The milling of flour, the ancient and the modern processes

In the old-fashioned process of milling, the entire kernel was ground between stones and the meal thus obtained sifted through screens covered with bolting cloth. Owing to the tough, fibrous nature of the bran, the greater part of it did not pass through the bolting cloth, but some, however, was pulverized, and hence could not be separated from the flour. In addition, the flour contained most of the germ, which owing to its high fat content greatly impaired the keeping qualities of the product. This old milling process gave what has been termed "entire" wheat flour, but owing to its rapid deterioration there was need for a better method, and so we find the roller process almost entirely replacing it toward the end of the 19th century. In the modern or roller mill process

a great many grades of flour are obtained, as against one grade in the old process. By this new method the wheat, after being thoroughly cleansed, is passed between a pair of corrugated rollers which simply break the kernel open; the whole of this product is then sifted through bolting cloth and the coarse part which does not pass through is sent to another pair of rollers set somewhat closer together. After the second crushing, the product is sifted again and the branny part returned to other rollers This process is repeated four or five times until practically all the starchy materials are separated from the bran. The flour thus obtained is practically free from both bran and germ and its keeping qualities have been improved, but unfortunately with a serious loss in food value.

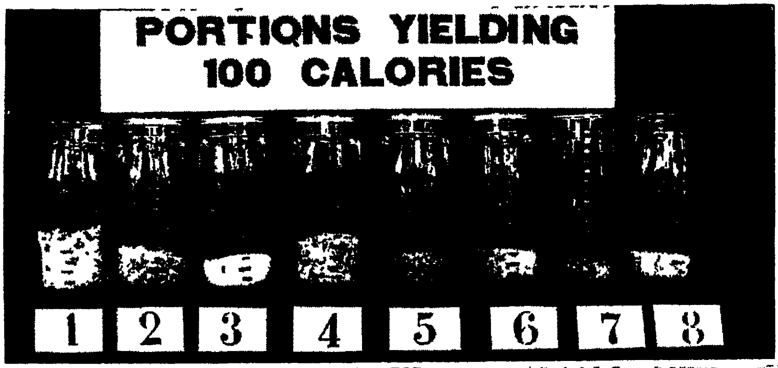
With each sifting the greater part of the endosperm is left in a coarse granular form which when purified may go to make farina, which is sold under a variety of names, such as "Cream of Wheat", a breakfast cereal. The bran separation is never quite complete in this process, and even the purest commercial bran contains about 17 per cent of white flour and germ. The germ also is not completely isolated in the milling process, and it has been estimated that only about 50 per cent of the mill product sold as germ is pure germ, the remainder being flour and bran in about equal proportions. Graham flour should be whole wheat finely ground but not sifted, thus containing all the nutrients of the entire grain. Entire wheat flour should contain the entire kernel except the coarsest of the bran. Many so labeled do not.

Value of the wheat and the other cereal proteins

Feeding experiments carried on by investigators with vigorous young rats have shown that the proteins of the wheat germ are more efficient for growth than those of the entire kernel, that the proteins of bran are apparently equal to those of the germ and that the proteins of the entire kernel are better than those of the flour portion alone. It was found that young rats failed to grow on diets in which the protein was entirely furnished by white flour, although the diet was adequate in every other respect, and was apparently sufficient to maintain adult rats. When the protein, however, was supplied by either the germ or the bran, the young rats grew, thus showing these proteins were more efficient for growth. Hence it is evident that the proteins of the germ and bran are better than those of the endosperm. Although the rats grew fairly well when fed the proteins of the entire grain, it was found necessary to supplement the diet with a better grade of protein in order to obtain normal growth. When milk, sufficient to supply one-third of the protein, was included in the diet, normal growth was obtained. These experiments indicate that when white bread only is used in a child's diet, the protein deficiency may be off-set by using an adequate amount of milk. The proteins of oats, maize and rice have been found to be of no better quality than those of wheat, and we may conclude that those of seeds will not support normal growth and will need to be supplemented by foods, such as milk, containing a better grade of protein.

The digestibility of cereal proteins as shown by experiment

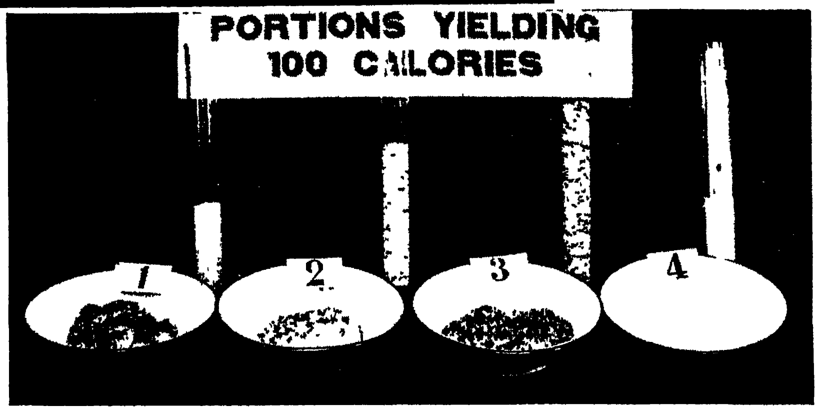
The proteins of the bran layers of the wheat kernel are enclosed in cells having thick walls which are not readily digested unless broken down and softened by cooking, hence the proteins of this region are not readily available for human food. Digestion experiments on healthy men have corroborated this. Bread made of white flour, entire wheat flour and Graham flour was used by the investigators for this experiment, and the average percentage of proteins digested is given as follows: 88.6 per cent of the protein of white flour was digested, 82.6 per cent of entire wheat flour and 74.9 per cent of Graham flour. Cattle and poultry on the other hand have digestive organs that can take care of tough cellulose and so are able to utilize these proteins more completely. The solubility of the proteins of the whole kernel seems to be increased by long cooking, and so in breakfast cereals made of the whole grain, such as rolled or cracked wheat and oatmeal or rolled



100-CALORIE PORTIONS OF VARIOUS RAW CEREALS

1 Rolled Wheat
2 Cracked Wheat.
3 Farina
4 Rolled Oats
5 Oatmeal
6 Cornmeal
7 Rice
8 Barley

All are in 8 oz jars



100-CALORIE PORTIONS OF RAW AND COOKED CEREALS

1 Cornmeal
2 Rolled Oats
3 Flaked Wheat
4 Farina

The corresponding raw cereal is behind and to the right (in 100 c c. graduates) of the cooked cereal (in cereal saucers)

oats, the total amount of soluble solids may be increased by the cooking process. The results of an experiment made to confirm this fact are reported as follows:

ROLLED OATS

Time Cooked	Method of Cooking	Soluble Protein	Total Soluble Solids
		%	%
Uncooked	—	0 86	8 43
20 minutes	Boiled	0.89	14 95
2 hours	Boiled and then cooked over hot water	1.57	18 79
5 hours		2.28	29 93
8 hours		3.39	34.30

This marked increase in soluble solids on prolonged cooking undoubtedly facilitates ease and slightly improves completeness of digestion, for the investigator found that 77.7 per cent of the protein was digested when oats were cooked for 20 minutes, when for 8 hours, 82.6 per cent. In addition, the flavor of these whole cereals is greatly improved, making them more palatable and hence digestible.

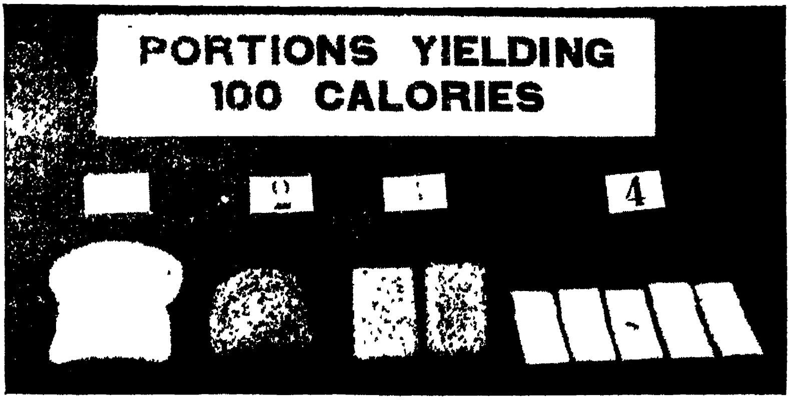
Mineral constituents

The amount of calcium, phosphorus and iron found in a 100-Calorie portion (see figures), or an average serving of cereals is given by H. C. Sherman in his "Chemistry of Food and Nutrition" as follows:

MINERAL CONTENT IN 100-CALORIE PORTIONS

Cereal Product	Calcium Gms.	Phosphorus Gms.	Iron Mgms.
Entire wheat kernel .	0 013	0.118	1.40
Graham flour . .	0.011	0.101	1.00
White flour . . .	0.006	0.026	0.23
Farina	0.006	0.035	0.22
Oats	0.017	0.099	0.96
Cornmeal	0.005	0.053	0.30
Rice—polished . .	0.001	0.027	0 26

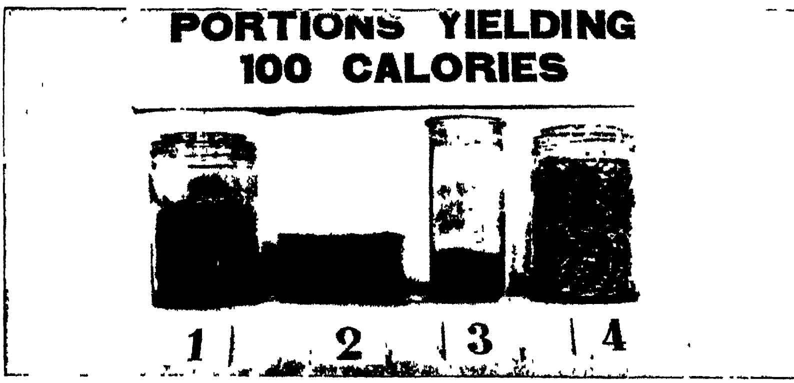
Calcium. The wheat kernel as a whole is exceedingly poor in calcium, and in the process of milling the white flour, more than half the calcium is removed. When vigorous young rats were fed with a diet in which whole wheat or other whole cereals



100-CALORIE PORTIONS OF BREAD AND CRACKERS

1 White bread
2 Graham bread
3 Graham crackers
4 Saltines

The slice of Graham is $3\frac{1}{4} \times 3\frac{1}{4} \times \frac{3}{4}$ inch, the slice of white bread is $3\frac{1}{2} \times 4 \times \frac{1}{2}$ inch, they are the same weight



100-CALORIE PORTIONS OF READY-TO-SERVE CEREALS

1 Toasted Cornflakes in pint sealer
2. Shredded Wheat biscuit
3 Grapenuts in 8 oz. jar
4 Puffed Rice in pint sealer

was the sole source of calcium — the diet being adequate in every other respect — the results obtained revealed the inadequacy of the grain with regard to calcium, since the rats failed to grow. When calcium salt was added to the diet, growth became normal again.

Phosphorus. The wheat kernel is the richest of all the cereals in phosphorus. A 100-Calorie portion of the entire kernel gives 0.118 grams of phosphorus but the same portion of farina yields only 0.035 grams or about one-third as much, and white flour gives still less Of the other common cereals, oats come next in order, then cornmeal and pearled barley have only about one-half as much as wheat, while polished rice is the poorest of all.

Iron. Reference to the table shows that wheat is the richest of the cereals in iron, but also reveals the great loss which takes place during the milling process and the importance of including the whole cereal in the daily dietary. While oats do not furnish as much iron as wheat does, they contain three times as much as a similar weight of cornmeal and four times as much as polished rice — in fact cornmeal and polished rice are deficient in iron. In cereals in general, the ash or mineral constituents are concentrated very largely in the germ and outer layers or bran coats, and since these two portions of the kernel are frequently removed in the process of manufacture, there is consequently a very great loss in phosphorus and iron, which are so essential to an ideal dietary.

Vitamin content

Vitamin A is present in a small amount in the wheat germ, although it is practically lacking in the bran and endosperm. The kernel as a whole is therefore deficient. In fact the wheat kernel is so poor in its content of this vitamin that if used as the sole source of vitamin A it fails to maintain growth in animals. This is generally true of all the cereals, and hence a cereal diet must be supplemented by foods rich in vitamin A, such as milk, butter fat, egg yolk and green leafy vegetables, in order to secure optimum well-being.

Vitamin B was discovered through the study of beri-beri. Investigations revealed the close connection between a diet consisting very largely of polished rice and the occurrence of the disease. Experimental work with pigeons showed that a similar disease — polyneuritis or beri-beri of fowls — was induced when the diet consisted of white or polished rice, but did not occur when whole rice or rice partially milled, but still containing the inner bran coat, was used It was not long before it was discovered that when rice polishings or the bran was added to the diet of polished rice the disease was cured.

Since we know vitamin B is found in rice polishings it is natural to expect to find it in the bran and germ of wheat. Investigators, using healthy young rats, have demonstrated the fact that the wheat kernel is quite rich in this vitamin, and when wheat kernel forms even 15 per cent of the diet, sufficient vitamin B is furnished to enable the rats to grow to full adult size. When, however, 60 per cent of the diet is composed of white flour there is not sufficient vitamin B to produce normal growth in the young. It is also known that a diet consisting too largely of white flour or white bread may cause beri-beri.

An instance of this occurred in the late war when, during the siege of Kut-el-Amara in Mesopotamia, the rations became limited. The disease was reported among the British soldiers but practically no cases were found among the native troops. The diet was composed principally of bread and canned beef but the British soldiers had bread made of white flour while the bread of the natives was made of a flour containing more of the bran and germ. When this latter bread was given to the British soldiers the disease was controlled until the siege was lifted and a more varied diet could be secured.

Hence it is readily seen that the value of cereals as a source of vitamin B depends on the part of the grain that is used. Polished or white rice is lacking in it while brown rice is a good source. Whole cereals, too, are a good source and as such should be included in the daily dietary.

Vitamin C. Scurvy has long been associated with a limited diet consisting principally of bread or other grain products and meat or fish When, however, the diet included fresh vegetables and fruits the disease became less common. Investigators found that guinea pigs fed exclusively on bread or grain developed scurvy, while those fed on carrots, cabbage and hay appeared relatively immune, showing that cereals do not contain vitamin C. The whole cereals then have no value as antiscorbutics nor are they a good source of vitamin A but are rich in vitamin B.

Cereal breakfast foods

The breakfast foods found on the American table at the present time are a modern invention, but they may all be traced back to the old-fashioned porridge which was made by simply boiling the coarse cereals in water for a very long time The old-time porridge was usually made of oat or wheat grains merely husked and cracked, but with the development of machinery these coarse grains were replaced by the so-called "rolled" oats and wheat, in which part of the cooking was done at the factory. This was of advantage to the housewife for the older products required a very long, slow cooking to make them palatable, which eventually became a problem as the cost of fuel increased. In response to the demand for breakfast cereals which could be easily and quickly prepared we have an ever increasing number and variety of these products on the market. No class of foods, perhaps, has been so widely advertised as these, nor had such astonishing claims made for them, yet their popularity seems assured for they are palatable and afford a pleasing variety in the diet

The grains commonly used in the preparation of the modern breakfast cereals are oats, wheat, corn, barley and rice, and although some of the preparations do not contain the whole kernel, others may be a combination of several of them The following table shows the distribution of calories in a 100-Calorie portion of some of these cereals in common use and it may be noted that one ounce is the approximate weight of such portions when dry.

Cereals	Calories from		
	Protein	Fat	Carbohydrate
Uncooked Products			
Barley	9.5	3.0	87.5
Cornmeal . .	10.0	5.0	85.0
Farina—Cream of Wheat	12.0	4.0	84.0
Hominy . .	9.5	1.5	89.0
Oats—Rolled or Oatmeal	16.0	16.0	68.0
Rice	9.0	1.0	90.0
Wheat—rolled or cracked	12.0	4.0	84.0
Ready-to-serve Products			
Grapenuts	12.5	2.0	85.5
Puffed Rice	6.0	1.0	93.0
Shredded Wheat	11.5	3.5	85.0
Toasted Cornflakes	6.0	4.0	90.0

All of these cereals may be grouped into one of two classes: (1) uncooked; (2) ready-to-serve The cereal foods requiring cooking include oatmeal, cracked wheat, farina, cornmeal, hominy and rice. Rolled oats and flaked wheat, the first to be introduced among modern breakfast cereals, also belong to this class, because although in the process of manufacture they are slightly cooked, yet not sufficiently to class them as cooked cereals. Oatmeal is prepared from the whole kernel, which is cleaned, hulled, dried and then cut into a fine meal; while in the preparation of rolled oats the grains after being cleaned are steamed for some time and finally run between rollers which press them into flakes. This preliminary cooking given these cereals in the manufacturing process shortens the time necessary to thoroughly cook them in the home, and hence they are now more generally used than the old-fashioned oatmeal or cracked wheat. The wheat farinas, sold under a variety of names, the best known perhaps being " Cream of Wheat", are obtained from the first and second breaks in the manufacture of flour. Cornmeal is a native American cereal and has been popular from very early times. In the manufacture of cornmeal the germ is generally removed, since, owing to its high fat content, it tends to make the meal rancid, and the corn is then ground into a fine meal. Yellow and white cornmeals are prepared from yellow and white varieties of corn. The process of manufacturing certain corn products varies in different parts of the country. For instance, in some parts hominy is prepared by coarsely grinding the whole kernel after only the hull is removed, while in other parts the product known as hominy has the germ and bran, as well as the hull, removed before grinding. The latter method gives a fine granular meal low in protein, fat and mineral constituents.

Preparation of ready-to-eat cereals

The cooked or ready-to-eat cereals, such as "Toasted Cornflakes", "Grapenuts", "Shredded Wheat" and "Puffed Rice", are prepared in a variety of ways, some being first cooked then dried and crushed, often toasted in addition, while others are rolled or flaked and then baked. The shredded preparations are steamed, then drawn out in shreds by special machinery, deposited in layers or bundles and baked. The whole grains may be cooked under pressure so that they puff or pop up, and form such breakfast foods as "Puffed Corn", "Puffed Wheat" and "Puffed Rice". Many of the devices used in the preparation of these ready-to-eat cereals are patented, and the products sold under proprietary names which may or may not suggest how they have been treated. In some cases sugar or molasses may have been added, and this tends to improve the flavor and perhaps the color to some extent. Practically all the toasted or parched cereals are sufficiently cooked to be eaten without further cooking, and because they are thus ready-to-serve have won an assured place in the American dietary. Some breakfast cereals have had malt added during the process of manufacture. Some of these malted cereals are ready-to-eat and others require cooking. Malt is the barley allowed to germinate until the ferment diastase has developed and then it is kiln-dried.

The diastase in malt, under certain conditions, has the power of converting the starch into dextrin and maltose, which are acted upon more easily by the digestive juices than starch itself. Thus in malted preparations the labor of digestion is somewhat reduced, and this may be an advantage for those who have weak digestion.

The proportion of starch changed to the soluble form by this process varies, depending upon the length of the malting process, and therefore many of the so-called malted preparations may not be more readily digested than any of the other thoroughly cooked whole grains.

Digestibility of ready-to-eat cereals

Digestion experiments which were carried out on healthy men to determine the digestibility of ready-to-eat cereals, have shown them to be no more completely digested than the other cereals. Digestibility and ease of digestion are different, however, and it was thought that the latter might be affected by the solubility, so experiments were made to determine the amount of soluble material in the ready-to-eat cereals as compared with rolled oats or farina. It was found that when rolled oats was cooked for five hours or farina for thirty minutes, there was as much or more soluble material as in "Toasted Cornflakes", "Shredded Wheat", "Force" or "Wheat Berries", and if the rolled oats was cooked for eight hours and farina two hours, considerably more soluble material was obtained. "Puffed Rice" and "Grapenuts" were the only preparations used that had a larger percentage of soluble material.

Some of the breakfast cereals have wonderful claims made for them, but is it reasonable to suppose that they could possibly have more nutriment than the grains from which they are made? "Cornflakes" are made from corn, "Puffed Rice" from rice and "Shredded Wheat" from wheat, and so these preparations could not furnish more fuel value, more or better building material, more vitamins or mineral constituents than the whole grains, and might possibly give much less owing to losses in manufacture. Therefore we may conclude that the only advantages of ready-to-eat cereals are (1) the time saved in home preparation, (2) additional palatability (although this is probably a question of the proper preparation of the whole grains), (3) increased need for mastication of these parched cereals; while the disadvantages are (1) possible loss in building material, mineral constituents and vitamins, and (2) their relatively high cost.

In conclusion, cereals and cereal products are very important as fuel foods, but no matter how complex or from what seeds they are derived, if used as the sole diet, they will never induce optimum growth. The quality of the protein is not sufficiently high, and must, therefore, be supplemented by foods, such as milk and milk products, eggs, fish or meat, which contain a better grade of protein. In addition, all cereals are deficient in calcium, vitamin A and vitamin C, and so the diet must provide foods which will offset these deficiencies. Cereals containing the whole kernel, however, are a rich source of iron, phosphorus and vitamin B and hence should always be included in the daily dietary.

HALLEY'S COMET AS DEPICTED ON THE BAYEUX TAPESTRY

WANDERING FIRE-MISTS

The Vast Journeyings of the Comets through Outer Emptiness, and Their Recall by Sun and Planet

VISITORS TOO SWIFT AND FINE TO BE KNOWN

THE majestic spectacle of the starry sky is too generally disregarded, but there are rare occasions when everyone is gazing heavenward. A golden shower of shooting stars attracts attention; an eclipse of the moon much more; but a notable comet has in all ages been the chief wonder of the night. Some comets are so bright as to be seen in full sunlight. Thus the famous comet discovered at Johannesburg on January 16, 1910, was a few days later clearly visible to the unaided eye, shortly after sunset. It then grew daily brighter and more impressive, and revealed a tail of enormous length, stretching upward from the horizon and slightly curved. The nucleus, a bright central condensation in the comet's head, was as large as the planet Venus and as bright as Mars. This nucleus was of a dusky red color, the surrounding nebulous mass of the head being of a fainter red, and the tail yellow. The comet had two tails; for, besides the main tail, which was a bright, fan-shaped jet of light projected toward the zenith, there was also a fainter and straighter secondary tail, short and bushy, and inclined about 20 degrees to the axis of the former. The main tail, which branched into two sharply curved streamers of equal splendor, was found by measurement to have a length, on January 29, of 62,000,000 miles, and extended, at its greatest length, for a distance of 50 degrees across the sky. This was one of the few bright daylight comets that have visited us since the beginning of the nineteenth century. Those of 1843, 1847, 1853, 1861 and 1882 are also famous in astronomical annals.

The magnificent comet of 1910 appeared at a time when the attention of many observers was concentrated on the movements of Halley's comet, which revisits our skies periodically, and had already been discovered on this visit as a faint nebulous body on a photograph in September, 1909, though it did not become visible to the unaided eye until early in February, 1910. By a strange coincidence, a similar appearance of some other visitant has marked several former returns of Halley's comet. This indeed, has happened so frequently as to make the tracing of Halley's comet in old records a difficult and complicated matter. Yet the history of the visits of Halley's comet has been well made out and has exceptional interest, because it gave rise to the discovery of the true nature of cometary movements.

On the appearance, in 1682, of the comet known by his name, Halley was the first to put forward the theory of its periodic return Up to that time it had been supposed that every visit of a comet showed a separate body, which had never before appeared in our sky and was destined never to return But Halley observed that the orbit of this comet of 1682 coincided very nearly with the orbits of the comets of 1607 and 1531, and found also that there were records of great comets having appeared in 1456, in 1301, in 1145 and in 1066. He recognized that although the intervals of time were not exactly equal in all cases, the differences were not greater than might be accounted for by perturbations due to the influence of planets.

Starting from these records, Halley ventured on the first prediction ever made with regard to a comet. He came to the conclusion that all these apparitions were the reappearance of the same comet at intervals of 75 or 76 years, and foretold that if his deductions were correct the next return might be looked for in the early months of 1759 Before that time arrived, mathematical calculations of a much more precise nature had become possible with regard to the probable influence of planets, and Alexis Claude Clairaut was able to predict what effect Jupiter would have in retarding the arrival of the comet. He fixed on April 13 as the date when the comet would pass nearest to the sun, but was careful to say that the possible action of other more distant planets, as yet unknown to astronomy, might retard or hasten it by a month. This was before the discovery of the two outer planets, Uranus and Neptune

The comet actually came to perihelion — that is, its position nearest to the sun — on March 13, 1759, thus establishing its identity with the visitants recorded in history, and proving the truth of Halley's theory of periodic comets We know therefore that the comet which was hailed as a gorgeous omen of victory for William the Conqueror, and is so depicted on the Bayeux tapestry, was Halley's comet itself, which last appeared in 1910.

Since Halley's brilliant discovery, more than twenty other comets have been actually observed to return in periodic courses, Encke's comet with a period of 3 years and 4 months, having been visible on more than thirty separate returns. The periodic nature of the orbits of many other comets has been demonstrated, though their return has not been actually witnessed. But of all periodic comets, Halley's remains by far the brightest and most important.

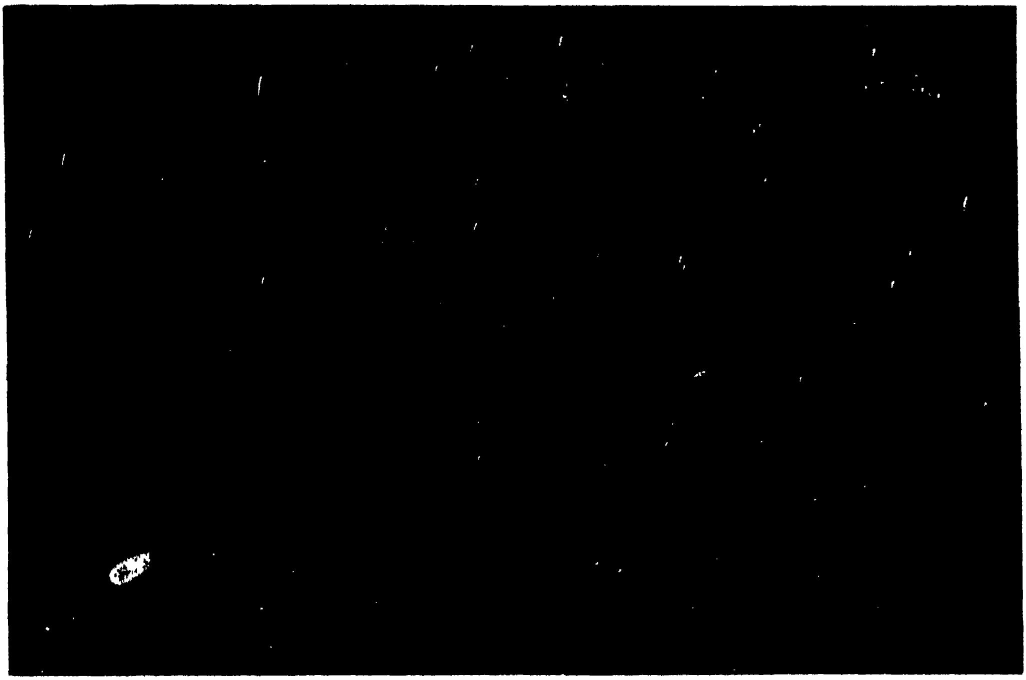
A PHOTOGRAPH OF THE COMET OF JANUARY, 1910, TAKEN AT THE LOWELL OBSERVATORY

The importance of this discovery will be understood when we realize that comets cannot be identified with certainty except by means of their orbits. There is nothing constant in a comet's appearance. The only feature of these bodies we have to

depend upon is their movement, and even that is difficult to calculate, because it is liable to all kinds of perturbations from the influence of the planets. These disturbances may be very violent, and may even result in the entire dissolution of the comet itself, or in a complete and unrecognizable transformation of its orbit.

The appearance of an individual comet is liable to extreme variations. It may appear at one time with a tail and at another time without any; it may be now very bright and again much fainter; the nucleus may be definite and brilliant like a star, or there may be no clearly defined nucleus at all. Indeed, all these and other changes may be observed in a comet during a single visit, at different stages of its progress. Its appearance, therefore, is no clue to a comet's identity; to establish this there remains only the determination of its orbit — that is to say, the path of its journey through space.

Before the discovery which was confirmed by the predicted return of Halley's comet, very various ideas had obtained with regard to the movements of comets. Aristotle, and many who followed him, regarded them merely as exhalations from the earth, which became ignited in the upper atmosphere. Some of the ancients looked upon them as living creatures, moving with self-directed motions; and from the earliest times down to a fairly recent date they were regarded as omens of disaster. It was not until the seventeenth century that the suggestion was made that certain comets moved in parabolas, but Halley was the first to conclude that there are comets which travel, like the planets, in elliptical orbits, and consequently return after regular intervals. Since then it has been proved that all comets move either in parabolic or in elliptical orbits, and therefore obey the universal law of gravitation



HALLEY'S COMET, PHOTOGRAPHED IN MAY, 1910, AT YERKES OBSERVATORY

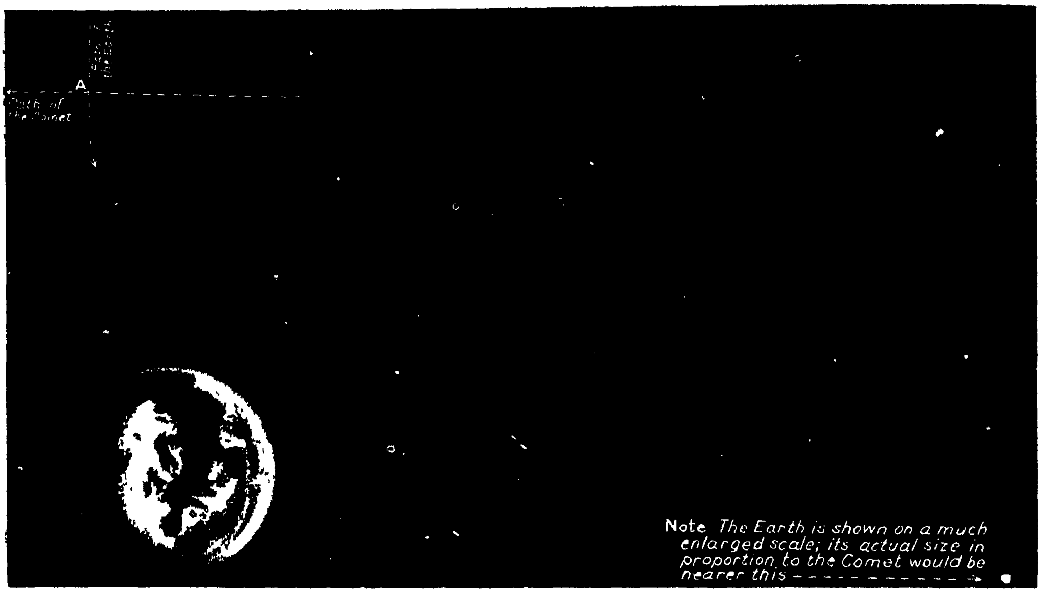
Comets thus fall naturally into two classes: those which return, and are known as "periodic comets", and those which do not return, the former moving in an ellipse, which is a closed curve, and the latter moving in a parabola or a hyperbola, open curves of which the ends never meet. But this does not imply that all the comets that have been observed can be classified as having parabolic or ellipti-

cal orbits W. H. Pickering made a very careful statistical study of all the well determined orbits known up to the year 1910 and found that out of 239 orbits 122 were definitely elliptical; 91 were to be classed as parabolic but among these many were very probably long ellipses, and that 62 were hyperbolic.

Inasmuch as over seven hundred comets have been catalogued, it is clear that the orbits of a large number have not been clearly determined. Moreover, the orbits of comets are at any time liable to be very considerably changed by the influence of any planet which they may approach; for the mass of a comet is so extremely small — that is to say, its body is so very light — that the vicinity of a planet is sufficient to alter its period by many years. By the same influence, a comet's orbit may be changed from a parabola to an ellipse, or from an ellipse to a parabola.

A comet is visible only through an extremely small section of its orbit — namely, when it is at that end of its ellipse or parabola which turns round the sun. It is therefore difficult to obtain, with accuracy, the measurements which are necessary for the determination of the orbit; and this difficulty is greatly increased by the size and nebulous form of a comet, which presents no definite point for measurement, except when the nucleus is very sharp and bright

Since a fairly large number of known comets apparently move in parabolas or hyperbolas and consequently cannot visit our sun more than once, unless their orbits are changed by the influence of the planets, it may be asked whether comets really belong to the solar system or are simply visitors from interstellar space. Earlier astronomers inclined to the latter view, but further investigations seem to show this is a mistaken view and that even the hyperbolic speed of some of the comets is due not to their having come from interstellar regions but to the perturbing influence of the planets It is the planets, chiefly the largest of them, which determine the character of cometary orbits. Thus, all the short-period comets, which return to us at intervals of from 3 to 8 years, pass close to Jupiter's orbit at some point in their path, and appear to have been captured, in a certain sense, by this planet's powerful influence. These, which number 34 according to Pickering's investigation, are known as Jupiter's family of comets. Saturn has a similar family of two, one of them with a period of 13 years,



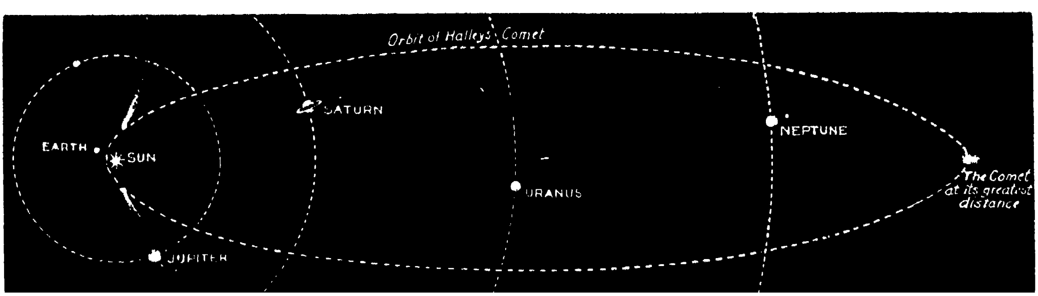
HOW OUR EARTH PASSED THROUGH THE TAIL OF HALLEY'S COMET IN 1910
The orbits crossed at A, so that the earth was only immersed in the extremely attenuated tail of the comet.

THE NUCLEI OR HEADS OF FOUR OF THE MOST FAMOUS COMETS
The comets appeared in 1858, 1861, 1874 and 1882, in the order shown.

Uranus two, Neptune six, including the three known comets with periods of from 70 to 80 years, among which is Halley's.

A comet moving in an extremely long ellipse or in a parabolic orbit and passing near a planet would have its motion either accelerated or retarded by the influence of the planet. If it were accelerated, the comet would pass out into space along a parabolic path or in a still wider curve — namely, a hyperbola; but if it were retarded its orbit would be reduced from a parabola to an ellipse, so that it would return again to the same position at regular intervals Successive encounters with the planet might in time result in reducing the comet's orbit to the small size of those of the short-period comets, though this result would take an enormously long time to come about. If, therefore, as is probable, the comets originally belonged to the solar system, and have not come to us from without, it follows that the total number of comets is slowly decreasing; for at least occasionally some comets while under the influence of the outer planets will have their velocity accelerated and their orbits rendered hyperbolic, so that they will disappear into outer space.

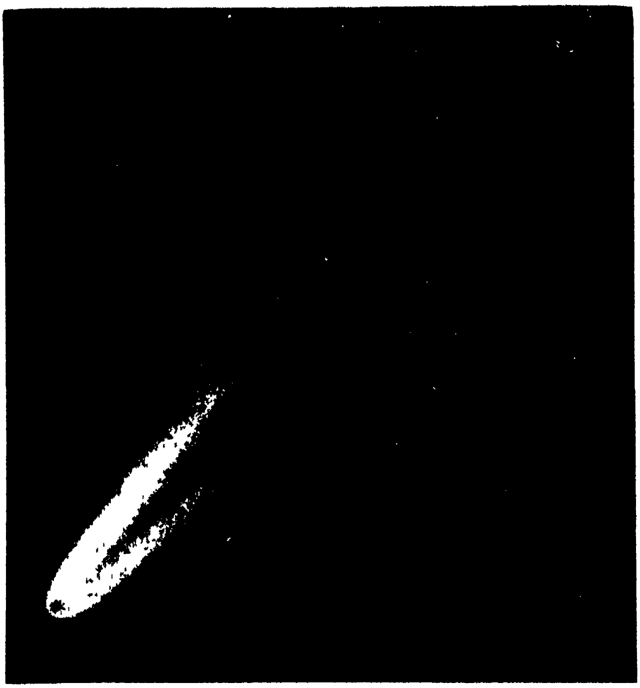
There are six or more peculiar and interesting groups of comets. In each of these the comets pursue apparently the same path, but follow one another too closely to be merely successive appearances of the same comet. It is therefore suggested that the several comets of any such group have a common origin, and that at some remote period they formed, or were parts of, a single body. Some of the famous comets of the last century belong to one group of that kind, namely, the comets of 1882, 1880 and 1843, and to the same group belongs also the comet of 1668. Now, the orbit of the 1882 comet was computed to have a period of from 600 to 900 years, so that none of the other comets of this group, though pursuing the same orbit, can be regarded as former appearances of this comet of 1882. As we shall presently see, considerations with regard to the physical constitution of comets, and various changes which have been observed in them, tend to support the view that several comets moving at intervals along the same path may have originated by the disruption of a single comet. Comets move either direct — that is to say, in the direction



THE ELLIPTICAL ORBIT TRAVERSED BY HALLEY'S COMET EVERY SEVENTY-FIVE YEARS

of the planets — or retrograde, and about as many travel in the one direction as in the other. But, with the exceptions of Halley's comet and the comet associated with the Leonid shooting stars, all the comets which have elliptical orbits with periods of less than one hundred years have direct and not retrograde movement.

A comet — so called from a Greek word meaning "long-haired" — consists of three parts more or less distinctly marked. These are the head, the nucleus and the tail. The head, or coma, is a faintly luminous nebulous mass, and is the first part to become visible as the comet approaches the sun. It has somewhat the appearance of a much blurred star. The dimensions of the coma are often enormous, varying from about 10,000 to over 1,000,000 miles in diameter. Even comets that can only be perceived through a telescope are seldom less than 40,000 miles in diameter, and are often much more, while some of the famous comets, visible to the unaided eye, have had heads larger than the sun itself. For instance, that of the comet of 1811 showed at one time a diameter of 1,200,000 miles, being nearly half as large again as the sun. On approaching the sun the head is nearly always seen to contract; part of this contraction may be merely an apparent change, due to the effect of the brightness of the sun in rendering invisible some portion of the luminous matter composing the comet, but the contraction is often too great to be so accounted for.

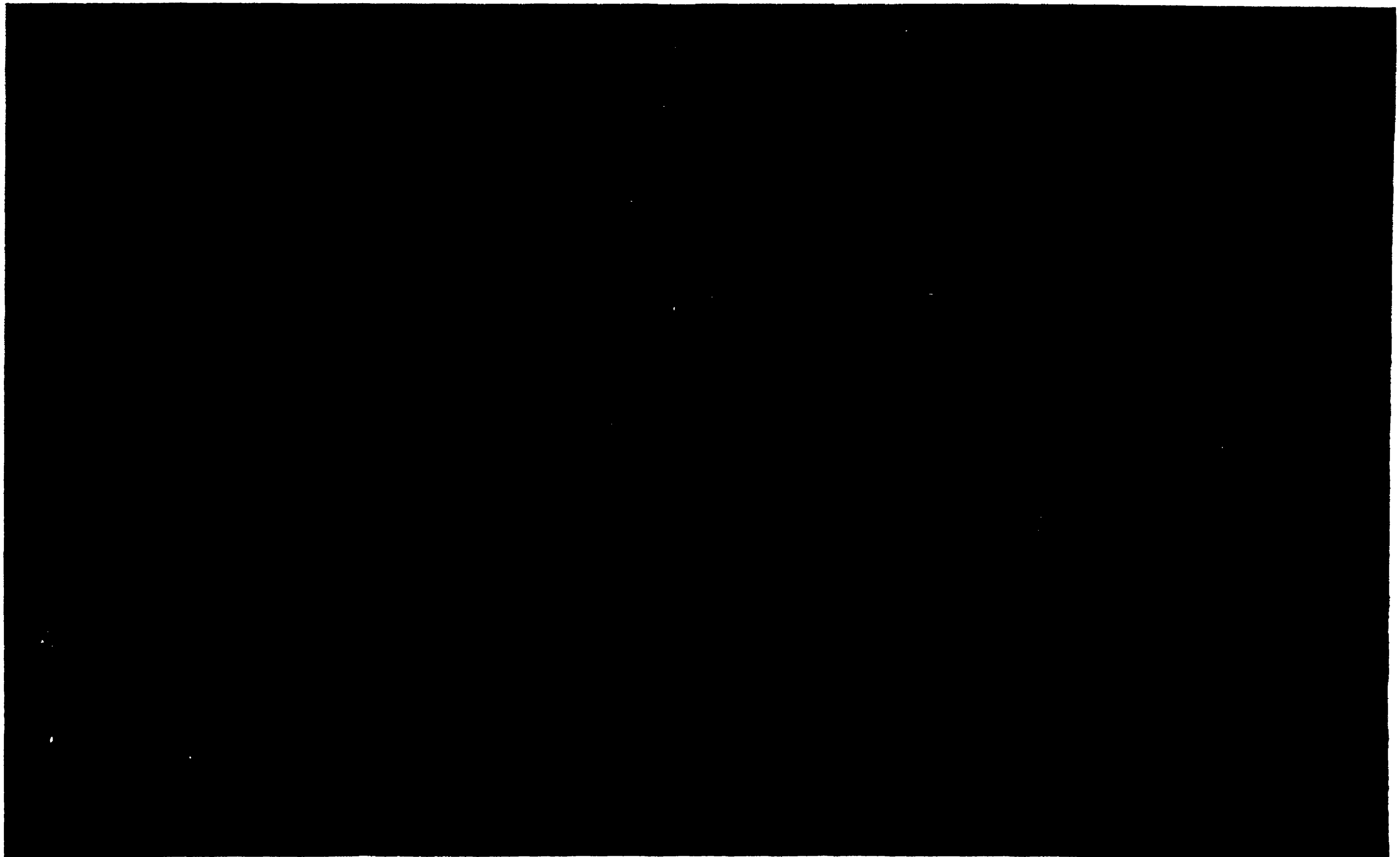


THE COMET OF MAY, 1901, AS SEEN IN TWILIGHT
Photographed at the Royal Observatory, Cape of Good Hope.

The nucleus, as has already been said, is a mass of condensed brightness within the head. It is not always present, or, rather, it is not always visible. It varies considerably in size, the largest on record having been that of an 1845 comet, whose nucleus measured 8,000 miles in diameter In some cases the diameter is as small as 100 miles. Frequent changes are observed in the nucleus as the comet progresses in its swing round the sun. It becomes more definite and brighter as it approaches, and shows signs of various forms of activity. Often it throws out jets of light on the side toward the sun, or gives off concentric envelopes of light, which widen out like circles made in water by a falling stone, to lose themselves in the general nebulosity of the head. Occasionally the nucleus has even been known to split up into several parts. This was notably the case in the comet of 1882, whose nucleus divided into four or five, presenting the appearance of beads strung together on a bright thread.

The tail of a comet is at once the most striking and the most puzzling part of its anatomy, and many theories have been put forward concerning it. The tail is often of enormous extent, sweeping over the heavens generally in a beautiful, plume-like curve of widening light. Those of several comets, including among recent examples the comet of 1882, have been found to exceed 100,000,000 miles in length, and at the extremity to be something like 10,000,000 miles in breadth. These are

WANDERING FIRE-MISTS OF THE HEAVENLY DEEP AS SEEN DURING ONE HUNDRED YEARS



1882 1811 1861 The Moon 1843 1858 1910 1874

SOME OF THE MOST CELEBRATED COMETS SEEN IN THE LAST CENTURY, SHOWING THEIR IMMENSE SIZE AS COMPARED WITH THE MOON

perhaps exceptional, but it is by no means unusual for a tail to attain the length of from 30,000,000 to 50,000,000 miles, and few, at their greatest length, fail to reach 10,000,000 miles The mere volume represented by these measurements is enormous, exceeding by hundreds or thousands of times the volume of the sun

But the mass or weight of these bodies is in comparison very small indeed They are of such exceeding tenuity that when passing in front of the faintest star the tails of comets do not diminish the star's brightness in the slightest degree. The

THE MOREHOUSE COMET ON OCTOBER 3, 1908

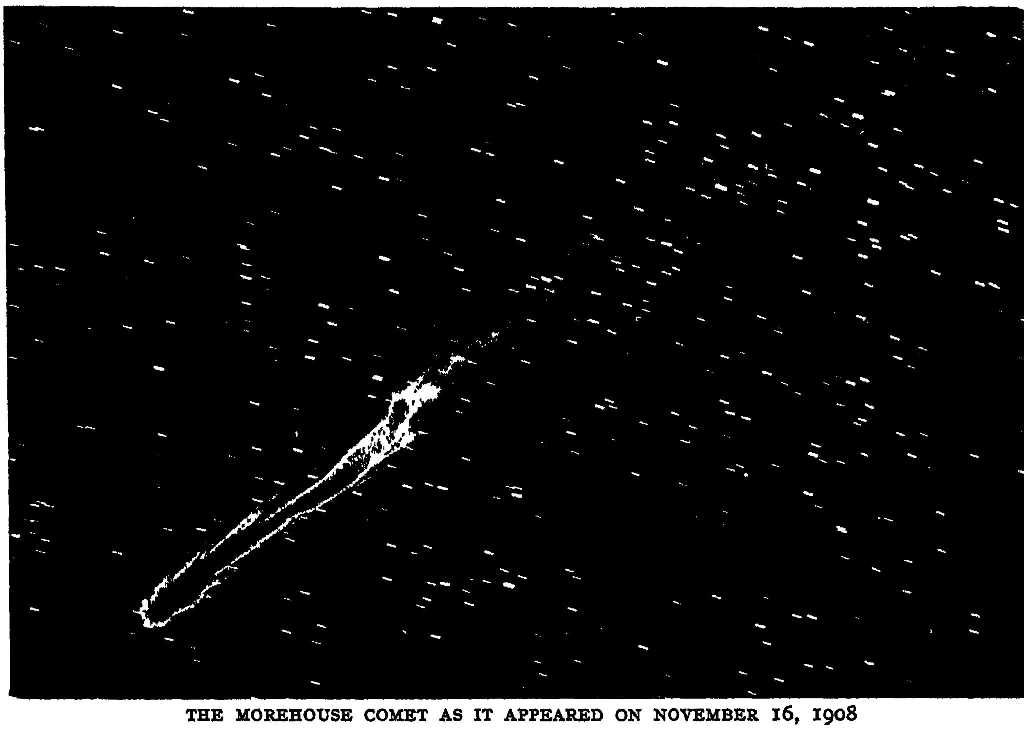
head, or coma, is equally transparent, with the exception, probably, of the nucleus. Another proof of the extraordinary tenuity of comets may be found in the fact that, although comets have passed quite close to various planets, and our earth has passed right through the tail of at least one comet, these delicate glittering things have never had the slightest appreciable effect upon the solid bodies they have approached or encountered. So far as the most exact measurements and calculations can go, a comet has never pulled a planet in the least degree out of its orbit, nor has it hastened or retarded it. The effect of a planet upon a comet, on the other hand, is often sufficient to alter its orbit entirely.

Since no effect whatever has hitherto been observed to be produced by a comet upon any other body, it is impossible even to conjecture any estimate of the smallness of its mass. We know at least that the mass of a comet must be very much less than one-100,000th part of the mass of our earth, for, otherwise, appreciable effects would have been produced by comets upon planets they have approached. It may be difficult for us, who are used to observing the motions of bodies only under the conditions of our atmosphere, to conceive how a body having such incalculably small density can move with such tremendous velocity as is shown by comets in their swiftest career; it would almost seem that these vast, filmy objects, weighing next to nothing, must be stopped at once

But we must remember that in general, throughout interplanetary space, there is no resisting medium whatever. When the air is withdrawn from a long tube closed at both ends and a feather and a bullet are released within it, the one falls to the bottom as quickly as the other. Where there is no resistance, a comet, which is far more unsubstantial than mist, may travel as swiftly and as freely as the solid earth. The tail of a comet does not, as we might be inclined to suppose, trail after the head, as a train of smoke trails behind a locomotive. It lies in a certain definite direction, which depends on the comet's position relatively to the sun. It points away from the sun, and is undoubtedly driven away by some influence from the sun. The tail, therefore, follows the head when the comet is approaching the sun, but precedes it when the comet is receding from the sun. Yet the tail is not usually quite straight, but describes a curve, convex to the direction of the comet's motion. This, at least, is the usual curve, but there are variations; for example, the curve of the tail of the 1910 comet lay concave to the direction of motion.

There are also two other types of tail, one or other of which is not infrequently seen together with the usual great plume-shaped tail One of these is the long, straight, ray-like tail, usually very faint; the other is the short, brush-like tail, very strongly curved, which was seen as the secondary tail in the new comet of 1910. The whole subject is still obscure, but there is little doubt that these three different types of tail consist of three different kinds of material.

It is generally believed that the tail of a comet is a hollow cone, and that it consists of solid particles, probably extremely small, each surrounded by a gaseous envelope. These particles are expelled from the nucleus, and are acted upon by some repulsive force from the sun. But besides these two repellent forces they are influenced also by the gravitative forces of the sun and of the nucleus. The effective result of all these forces, which produces the form of the tail, is due to the proportion the respective forces bear to one another; and this proportion, in its turn, depends upon the nature of the particles that form the tail.



THE MOREHOUSE COMET AS IT APPEARED ON NOVEMBER 16, 1908

A comparison of this photograph, taken by Barnard at the Yerkes Observatory, and that on the opposite page, taken at the Royal Observatory, Greenwich, shows the alteration in the form of the tail.

Bredikhine, a Russian astronomer, brought forward a very ingenious theory which has thrown some light upon the perplexing question of the tails of comets. He supposed that the repellent force of the sun acts only upon the *surface* of the particles, and that its power is consequently proportional to the surface of the matter upon which it acts. The gravitative force of the sun, on the contrary, is proportional to the *mass* of the matter upon which it acts, and is quite irrespective of the extent of surface. The effective force, on this theory, would evidently depend upon the ratio the surface of the particles bears to their mass. If the particles had a large surface in proportion to their mass they would be repelled more powerfully than if they were of denser material, and so had a smaller surface in proportion to their mass. But it has been found that the molecules of hydrogen, of hydrocarbon gas and of vapor of iron bear to one another such a relation in re-

spect to this ratio of surface to mass as would produce the respective forms of the three types of tail. Bredikhine therefore supposes that the long, straight tails are composed of particles of hydrogen; the great, plume-shaped tails of some hydrocarbon gas; and the short, violently curved tails of iron vapor, probably with some admixture of sodium and other materials.

Spectroscopic tests have more or less supported his theory, though they are not conclusive in the matter. The spectroscope has shown the presence of hydrocarbon in some plume-shaped tails, but analysis of the light from the tail of Halley's and other recent comets has shown that hydrocarbons are only variable constituents of comets, because the characteristic band of hydrocarbon gas is only an occasional feature of their spectra. The spectrum of the tail has been reproduced in that of carbon monoxide at very low pressure, while the same gas at a higher density gives a spectrum very similar to that of the heads of comets. A great deal of thought has been given to the question of the nature of that repellent force from the sun which is chiefly responsible for the form and movements of a comet's tail, but beyond the fact that it is due to some form of electrical or light energy there is little agreement on the subject.

The belief that the tail consists of matter ejected by the nucleus is supported by many observations of the activity displayed by the nucleus under the influence of the sun. This activity is greatest when the tail is being most highly developed. The matter thus thrown off by the comet to form the tail, must be eventually lost, leading to the gradual diminution of the comet, and perhaps at last to its total disappearance.

The source of the light of comets has been much discussed. Do they shine by some intrinsic light, or by reflected sunlight only? The answer is that while the comet's light does depend, in some degree, upon the sun, it is not merely reflected sunlight. Two facts prove the dependence on the sun for light. In the first place, the light which we receive from the comet is partially polarized, showing that it is, in part, reflected light. In the second place, the comet diminishes in brightness as it recedes from the sun; whereas if it shone only by its own light it would grow smaller as it recedes, but would not diminish in brightness.

On the other hand, the comet's light is partially generated by itself Spectroscopic examination proves that it is not merely reflected light. But the same fact is shown also much more clearly by the capricious changes which take place in its brilliancy, quite independently of its position in relation to the sun A comet is sometimes seen to flash out with seven or eight times its normal splendor, and then after some hours to return to its normal brightness, or perhaps below it. These sudden variations, for which no external cause can be traced, reveal the presence of some inherent light, produced from the materials of the comet under the influence of the sun.

Little is known, after all, with regard to the constitution of comets. But the discovery in recent years of a very close relationship between comets and swarms of meteors goes far to support the conclusion, already adopted by many astronomers, that a comet is an enormous collection of small, solid particles, probably quite minute in size, separated widely from one another, and each surrounded by a gaseous light-producing envelope.

The most striking evidence in support of this relation between comets and meteors is the history of Biela's comet. This was a very small comet, visible only with the aid of a telescope, having a short period of about 6½ years, and was first observed in 1826. It was again seen in 1832, but was not seen on its return in 1839, owing to its unfavorable position in the sky. In 1846 it presented at first the ordinary appearance, but on December 19 it was seen to be somewhat pear-shaped, and by the 29th of the same month it had divided into two separate comets. For four months or longer the two companions were observed to travel side by side, at a distance of about 160,000 miles from one another, each having a bright and

very active nucleus There appeared to be no attraction between the two, nor any perturbing action of either upon the other, but it was noticed that when one grew brighter the other became fainter, in a curiously alternating manner. For part of the time an arc of light connected them.

In 1852, the date of the next return, both comets were seen at a distance apart of about 1,500,000 miles Neither of them has since then been seen, although if they had duly returned they must have been easily observed on several visits. On November 27, 1872, as the earth was passing across the path of this comet, it came into a remarkable meteor shower; and on crossing the same path again in November, 1886, a similar shower was encountered. There can be no doubt that these meteors bear some relation to the lost Biela's comet; and the simplest explanation seems to be that they are actually the disintegrated particles of the comet itself.

The most striking comet of recent years was the great comet of 1882, which showed many curious and unusual features, and was, besides, of exceptional beauty and brilliance. Its light was so powerful that it was clearly visible in broad daylight, even when quite close to the sun It remained visible from September, 1882, to March, 1883, and was seen with the telescope to a distance of more than 470,000,000 miles from the earth, so that astronomers were able to determine its orbit more accurately than usual. It moved in a very elongated ellipse, with a period of about 750 years. The nucleus was particularly interesting. At first almost round in form, it became elongated until it had assumed the shape of a long streak with several bead-like enlargements upon it, one of the beads being 5000 miles in diameter, and exceedingly bright. The chain of beads lengthened until it extended over a distance of 100,000 miles The tail of this comet was at one time more than 100,000,000 miles in length, and was marked by a bright streak along its central line, extending from the bright chain of the nucleus. An unprecedented feature of the comet was a broad beam of faint light which enveloped the head and projected straight in front of it for several degrees. After passing around the sun it was found to have several nuclei instead of one, and a number of observers saw half a dozen or more cometary bodies accompanying the great comet at a short distance; and these are supposed to have been given off from it — a conclusion which appears to be supported by the history of Biela's comet.

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THE HARVARD OBSERVATORY AT AREQUIPA, PERU, WITH EL MISTI (19,200 FEET) IN BACKGROUND

WEATHER ON THE SAME DAY EAST AND WEST

NEW YORK WRAPPED IN SNOW

CALIFORNIA BATHED IN SUNSHINE

These photographs were taken on the same day in the same latitude. The difference in mean temperature was 60 degrees.

THE WEATHER MYSTERY

Dependence of Climate on Balance Between Power of the Sun and the Shelter of the Atmosphere

AT THE COOLING POINT IN THE EARTH'S LIFE

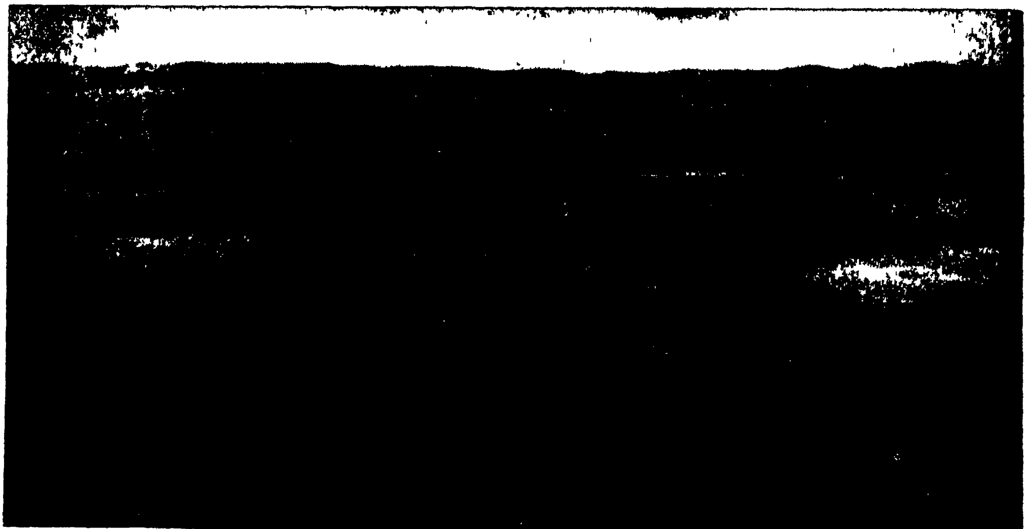
ETYMOLOGICALLY the word "climate" implies inclination, for man long ago recognized the meteorological importance of the inclination of the sun, but the term has now a much more comprehensive significance Wind, rain, dust, humidity and all meteorological factors relevant to man's comfort or health, are included in the conception. Humboldt defined climate as "all the changes in the atmosphere which sensibly affect one's physical condition", and Hann as "the sum total of the meteorological phenomena that characterize the average condition of the atmosphere at any one place on the earth's surface". It is, in fact, the *tout ensemble* of meteorological conditions considered from the double standpoint of geography and physiology. But a distinction must be drawn between weather and climate; the daily meteorological mean with respect to temperature, humidity, etc., of the atmosphere we must regard as weather, reserving the term "climate" for the seasonal or annual mean. We talk of bad weather if it rains from morning to night, and of good weather if there has been no rain for a week; we talk of a good climate when in any place all meteorological phenomena conspire on the average for man's comfort and health; and we talk of a bad climate when on the average they conspire against it.

The mainspring of the climate is the mutual relationship between earth and sun. The size and shape of the earth's orbit, the rotation of the earth on its axis, the inclination of this axis to the plane of the earth's orbit about the sun, condition the climates of the world. Were the size of the orbit of the earth doubled, its climates would be completely altered. Were it halved, we could scarcely talk of climate at all The heat of the sun is at the back of all meteorological phenomena; and the amount of heat which reaches the earth, and the relative intensity of the heat experienced at different seasons and in different latitudes depend chiefly on the factors just mentioned.

Life on earth, and the climates that favor life, are confined to a small portion of the total thermal changes that our planet has experienced. Between the heat of the sun and the absolute zero there are thousands of degrees. But the limits within which life obtains are separated only about 250°. We are rather inclined to claim for the earth the whole heat of the sun, but the total heat radiated into space by the sun is terrific, and if concentrated on our globe would not merely heat the earth, but would soon change it to a mass of vapors. Were we to clothe the sun in a mantle of ice two miles thick, in two hours and a quarter it would be entirely melted. Were we to lay a column of ice two and a quarter miles in diameter between the earth and the sun and to focus upon it all the heat of the sun, in a single second it would be water, and in seven seconds more it would be water-vapor — the whole column of ice, 93,000,000 miles long, would be gone in a few seconds. We do not need all this heat — it would be fatal to life; and of the total radiant energy of the sun the earth receives less than one-2,000,000,000th part — just the minute fraction necessary to insure a climate favorable to life.

Let us look now at the climatic significance of the orbit of the earth. The orbit is not an exact circle; it is what is known as an ellipse; it is a circle flattened so that it has a longest diameter and a shortest diameter at right angles to each other, which divide it into equal parts This ellipse is very nearly an exact circle, the long diameter being only .014 per cent longer than the short diameter. Such a small departure from a true circle is this that "if a circle three inches in diameter were drawn with a very sharp pencil, making a line one-5000th of an inch thick, it would represent the orbit correctly, the difference between the ellipse and the circle being concealed by the thickness of the line".

The orbit is not quite fixed; it varies in rhythmic fashion. For about two hundred and fifty thousand years it becomes gradually more and more circular, and then for two hundred and fifty thousand years it becomes gradually more and more elliptical The sun is situated not quite at the center of the orbit, but at a point on the longest diameter about 1,550,000 miles from its middle; and as the orbit approximates a perfect circle, the sun approximates a central position; and as the orbit becomes more elliptical, the sun becomes more eccentric. The eccentricity of the sun on the long diameter of the ellipse brings it nearer one end of the ellipse: and as the earth crosses the long diameter at this end, it is nearer the sun than in any other point of its orbit, while, as it crosses the long diameter at the opposite end, it is further away. The point of the orbit where the earth is nearest the sun is known as its "perihelion", and the point where it is farthest away is known as its "aphelion". Between perihelion and aphelion the earth gradually recedes from the sun, between aphelion and perihelion it gradually approaches it. At present the earth in aphelion is 94,450,000 miles and in perihelion 91,340,000 from the sun; that is, it is 3,110,000 miles nearer the sun at its nearest than at its farthest point.



LOOKING DOWN FROM DARJEELING ON THE WARM CLOUDS THAT THE MONSOONS BRING TO INDIA

Round this elliptical orbit, alternately approaching the sun and receding from it, rushes the earth at a rate of eighteen or nineteen miles a second. Now, it might be thought that differences in the distance of the sun must mean differences in the amount of heat received by the earth, and must therefore have important climatic consequences One might think that when the earth is in aphelion it should be much colder than when it is in perihelion, and that when there is a maximum of eccentricity there should be a maximum of difference; and, indeed, on a supposition of this sort, attempts were made to explain the glacial periods.

But, as a matter of fact, the different distances of the earth from the sun are not of great climatic importance. Winter in the northern hemisphere occurs when the earth is in perihelion and hence nearest the sun, and summer when the earth is in aphelion and furthest from the sun; and, as is well known, it is cooler on the top of high mountains than in the plains below. The factors that modify the climate and that mitigate or aggravate the heat of the sun are the atmosphere, the relative length of day and night and the greater or lesser inclination of the rays of the sun to the surface of the earth. The daily differences between the heat of noon and even of day and night, are of the same nature as the differences between summer and winter, and as the main differences that distinguish climates. And these daily differences are a matter of the rotation of the earth and of the angle at which the sun's rays penetrate the atmosphere and fall upon the earth at different times of day.

Let us look now at both these matters — at the manner of rotation of the earth and of the penetration of the atmosphere by the sun's rays First, as to the manner of rotation of the earth. It revolves once on its own axis in about four minutes less than twenty-four hours. Were the axis of rotation perpendicular to the plane of the earth's orbit, every point on the earth's surface would have twelve hours day and twelve hours night, and for any given place the sun at noon would be day after day at the same height in the sky — *e g*, at the zenith for any place situated on the equator, and 49° 15′ above the horizon at New York or any place on the same circle of latitude. Every day, to every place, the sun would supply a certain quantum of heat; and though the amount would vary greatly from place to place, it would not vary much from day to day.

The heat, we say, would vary from place to place. Why should it vary? The same sun shines upon Timbuctoo and upon Klondike — the same sun at practically the same distance. Why should the heat vary? It would vary simply because of the varying inclination of the sun's rays. Every day, as we know, it is hotter when the sun is high in the sky, and cooler as the sun sinks. The same principle would be at work here. The sun shining upon Timbuctoo would have a higher arch in the sky than the sun shining upon Klondike. The higher the latitude, the lower the sun's arch and the less the sun's heat, but every place would have a nearly constant temperature all the year round. Why, it may be asked, should the height of the sun in the sky, and the obliquity of the sun's rays, have such a marked effect on the temperature?

THE WINTER COLD THAT THE MISTRAL BRINGS TO FORT NATIONAL, IN NORTHERN ALGERIA

The reason is twofold First, a beam of light falling vertically is spread over a smaller surface than if it fell obliquely, and is therefore more concentrated and has more heating power. One which, falling vertically, covers an area of a square inch, will cover two inches if it fall at an angle of 30°, and will have half as much heating power per inch. Second, the oblique rays have to pass through a greater thickness of atmosphere than do the vertical rays, and in their passage heat is absorbed and radiated back to space

If, then, the earth rotated on an axis perpendicular to the plane of its orbit, climate, as regards heat received from the sun, would be mainly a matter of latitude; and in each latitude there would be a constant quantum of heat received every day, barring a variation of about $\frac{1}{10}$ of one per cent due to the varying distance of the sun. But the matter is not so simple as that The axis of the earth's rotation, as we know, is inclined to the plane of its orbit; and the result of this inclination is that the sun gradually in the course of the year moves northward across the celestial equator to declination 23° 27′ N., and then appears to turn and move southward across the equator to declination 23° 27′ S

A STREET SCENE IN BISKRA, IN THE ALGERIAN SAHARA, ONE OF THE HOTTEST SPOTS IN THE TEMPERATE ZONE

The effect of this movement is obviously to increase and decrease the height of the sun above the horizon, from day to day, in all places, in both hemispheres. From about December 21, the so-called winter solstice, to about June 20, the so-called summer solstice, the sun moves northward, and day by day the sun makes a larger, higher arch in the sky in all places in the northern hemisphere, and a lower arch in all places in the southern hemisphere · from the summer solstice to the winter solstice the sun moves southward, and day by day the sun makes a higher arch in the sky in all places in the southern hemisphere, and a lower arch in all places in the northern hemisphere The result of this is, of course, that heat and daylight increase to a maximum and diminish to a minimum, from day to day, in each hemisphere alternately, and thus we have our seasons, and thus the climate in any place is not merely a matter of its latitude, but also of the varying declination from day to day and month to month of the sun itself On March 21 or within a day of that date, we have the vernal or spring equinox, and on or about September 23, the autumnal equinox; at these two dates the sun crosses the celestial equator, and then night and day are equal all the world over.

The main cause, accordingly, of the varying heat of the varying seasons is not the sun's varying distance from the earth, but the height it attains above the horizon of any place at any time; and the variation in this height from day to day due to the northward and southward march of the sun gives rise to the seasons—*e.g.*, a winter with short days, long nights, and oblique sun-rays, and a summer with long days, short nights, and more perpendicular sun-rays.

Seeing the radical relationship between sun-heat and climate, attempts were made long ago to divide climates into zones, according to the length of the longest day. Nearly eighteen hundred years ago Claudius Ptolemy, author of the "Ptolemaic System of the Universe", divided climates into zones in which the length of the longest day increased successively by half an hour between the equator and the Arctic Circle. The zones thus delimited varied greatly in extent, for the first zone embraced $8\frac{1}{2}$ degrees of latitude and the twenty-fourth only one-20th of a degree; and further, the division did not really give much information as to the general climate of any zone, for though the heat of the sun is distributed according to length of day, many local factors alter the ultimate result. Let us look at some of these local factors.

As we have already said, the diminution of heat consequent on the obliquity of the sun's rays is due partly to the impediment offered the rays by the atmosphere and its contents. How great the impediment is is shown in a variety of interesting ways Thus the very fact that light is white and that the sky is blue is due to atmospheric interception of the sun's rays. Were the rays of the sun not sifted by the dust in the atmosphere, sunlight would be blue and the sky itself black. The full physiological significance of the atmosphere filter we do not yet quite know, but we do know that a large percentage of the rays of the sun is obstructed by the atmosphere, and that without this obstruction the sun's rays would be intolerably powerful. When the atmosphere is moist, and when clouds are formed, the hindrance to the passage of heat is much increased.

DEATH VALLEY, INYO COUNTY, CALIFORNIA

Combines greater heat and aridity than any other region in the world The name perpetuates the fate of a party of "forty-niners" who perished there from thirst, starvation and exposure The valley is 276 feet below sea level, 150 miles long and 15 to 20 wide The mountains are high, 10,937 feet maximum, of brilliant coloring It is the sink of the Amargosa River, which enters it from the south and disappears in the salty bottom of a former lake. The rainfall is not over 4 or 5 inches in a year and the temperature registers as high as 125° F. in the shade for days successively

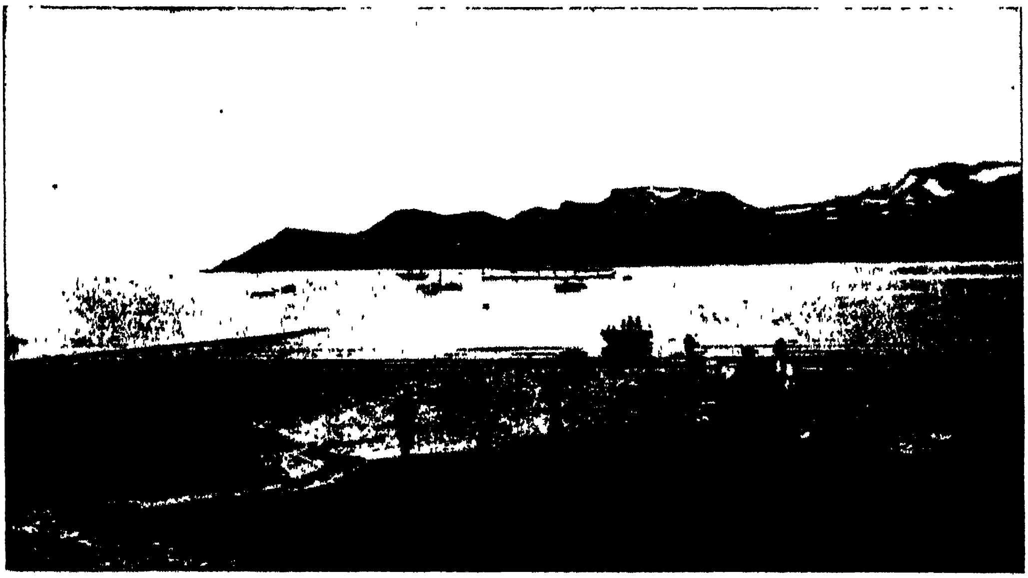
There is no doubt that the selective absorption of the rays is of great climatic importance. And in different parts of the same zone it necessarily varies to a great extent with the varying height above sea level of any district or country.

The effect on the climate of diminished absorption of the sun's rays is not at all what we at first sight would expect. Since more sun-rays pass through the air and reach the earth, it would seem at first sight that this must mean a hotter climate. As a matter of fact, it means just the reverse, as a thousand snow-clad peaks inform us. How is this? The reason is simply that in considering the average temperature of any place we have to take into account not only the heat it is given, but its retentiveness of heat. Most of the rays which are absorbed by the atmosphere are absorbed by its lower, denser layers; and all these rays, when absorbed, are transformed into heat and warm the air-molecules. The warm air-molecules of the lower atmosphere, accordingly, act as a warm blanket, and keep the earth warm during the night; whereas the higher atmosphere, being less dense, retains less heat, and is a much less efficient blanket. It is true that the sun beats with more power upon the earth when a thinner layer of atmosphere intervenes. At an elevation of 11,000 feet, water can sometimes be boiled (its temperature then being about 185° F) by putting it in a blackened bottle, and placing the bottle in the sun. But the fact is that the mountain tops are *not* blackened, and, though they may get an abundance of sunlight, they simply radiate it away again.

Not only the rarity of the upper atmosphere, but also its dryness, affects radiation of heat. The moister and cloudier the atmosphere, the more does it absorb heat radiated from the earth, and radiate it back again After a warm, sunny day the night will probably be cool if cloudless, and warm if cloudy. The rapidity, indeed, with which heat can radiate away through dry air is amazing. Dr Robert Brown, in "Our Earth and Its Story", gives the following remarkable instances: "In the Sahara the skins of water are often frozen before daylight, though the heat of the preceding day was more than 70° above freezing-point. At Murzuk, the capital of Fezzan, in northern Africa, the thermometer will sometimes show a temperature of 133° in the shade. Yet just before daybreak, Lyon and Rohlfs tell us, it will sometimes fall, during the month of December, 7° below the freezing-point, owing to the unchecked radiation from the heated soil. Snow

THE MAIN STREET OF VERKHOYANSK, SIBERIA, NOTED FOR ITS COLD CLIMATE

also has been known to fall so heavily in the same region that in January, 1850, the flat roofs of Ghadames and Sokna, far in the desert south of Tripoli, fell in from its weight In the Atacama Desert, the temperature of the ground is frequently 145° at midday, and even in winter the thermometer will register 98° in the shade, though four hours before it stood at 7°, this sudden change being, as in the cases mentioned, due to the rapid radiating going on in this extremely dry climate." Very different, indeed, are the climates of the Sahara and the Red Sea, yet both are in the same latitudes; and very different would be the climate of Tripoli if those as well as the atmosphere, since soils have widely varying capacities for heat. It is very generally considered that sandy soils are healthy, because dry, and that clayey soils are unhealthy, because damp, but, on the other hand, it must be noted that clayey soils are warmer than sandy soils The surface layer of sand is quickly heated, but sand is always mixed with considerable quantities of air, which is a very bad heat-conductor, and only the surface of the sand gets heated. The top of the sand, therefore, gets very hot, and may be heated up to 150° or 160° F., but the heat is only skin deep, so to speak, and soon radiates away Clay, on the other hand,



ANDO, IN THE MILD LOFOTEN ISLANDS, IN THE SAME LATITUDE AS VERKHOYANSK

parts of it which lie below sea level were flooded with the Mediterranean. At high elevations the air is necessarily dry, and its dryness, as well as its rarity, favors the radiation of heat. One-half of the moisture in the air is below 6000 feet, and only one-tenth above 20,000 feet. Above a certain height, accordingly, the air is always very cold, and the temperature continues to fall as higher altitudes are reached until, at about six miles above the earth, we reach the region of constant temperature where the thermometer always registered about −70° F.

But, besides the blanket, we must consider the baby; in other words, the soil is a compact soil and a good conductor of heat, so that the heat spreads downwards more rapidly and to a much greater depth. And so, after a hot day, clay may give off heat from its underground stores for a long time, and this is especially the case if it be water-soaked. If the Sahara Desert had clayey, not sandy, soil, the days would be cooler and the nights much warmer. Again, if the ground is covered with grass, it will take in heat more slowly and give it out more slowly than if bare.

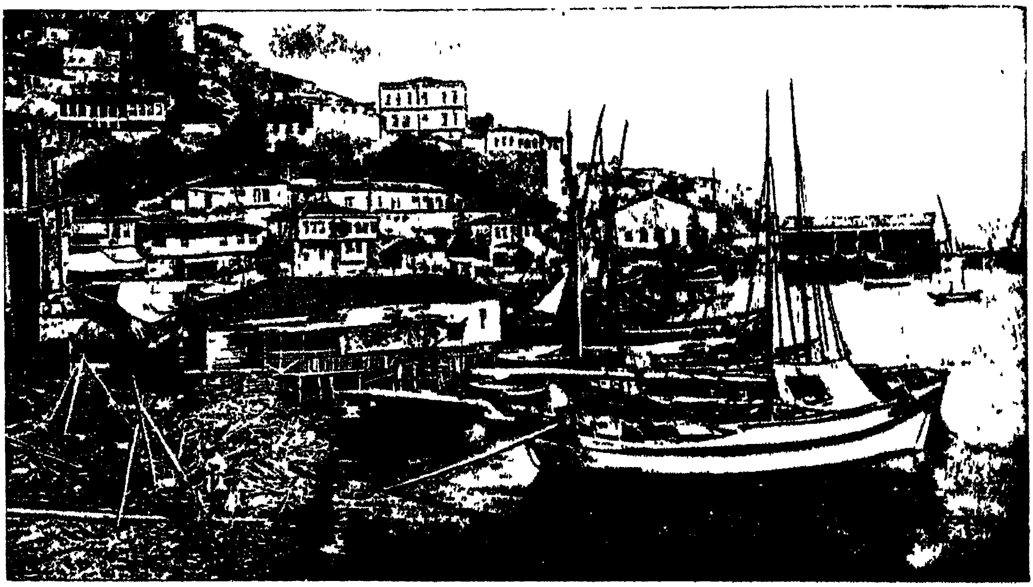
The capacity, then, of the soil for heat must be allowed for. But most important in the final average of heat is the distribution of land and water.

According to Professor Moore a given amount of heat will raise the temperature of a land surface four times as high as that of an equal water surface Land is a good absorber and a good radiator but it conducts and reflects poorly Large land areas then retain their absorbed heat near the surface and quickly radiate it These conditions cause, in interior land tracts, a greater daily and seasonal variation in temperature than is found in sea-coast or island climates of the same latitude. For example, the Bermuda Islands have a mean daily range of only 10° F, and an annual range of 50° F; while Memphis, Tennessee, near the same latitude, but 700 miles from the coast, has a daily range of 17° and an annual range of 112°.

So island and sea-coast climates are usually equable climates, without great extremes of temperature.

But the sea warms not merely as a hot-bottle; it acts also as a system of hot-water heating, for its currents carry hot water and cold water all over the world England and Norway, as we know, are warmed by sea water carried by the Gulf Stream and other great ocean currents. Alaska and the Aleutian Islands are warmed by an equatorial current, the Kuro Sivo, which reaches them via Japan On the other hand, the coast of Chile and Peru and the west coast of Patagonia are kept cool by Humboldt's Current, which comes from the Atlantic.

More important as carriers of heat even than the currents of the sea are the winds We all know how cool breezes may temper great heat; and it is hardly possible to consider heat apart from wind. The "bora", blowing down from the Julian Alps, quickly turns summer into winter, the mistral makes Algiers take to furs and fires The foehn visits the Alpine sport-centers in mid-winter, and the snow melts like butter on a frying-pan The sirocco withers whole vineyards in a moment. It is the monsoons that make the seasons in India — indeed, the name means season; and were India not protected from north winds by the Himalayas its climate would be very different



MUSCAT ON THE PERSIAN GULF, A TORRID TOWN IN THE TORRID ZONE

Because, then, of all these variable local factors which influence temperature, it is not possible to divide climate into zones even in respect to temperature. We can in a rough way distinguish between torrid or tropical zones, frigid or polar zones, and temperate zones, but the divisions will not be mutually exclusive, and any approximately true division lines will not be straight. Still, this rough distinction is of some value.

Extremes of temperature noted between different latitudes

We may divide off a torrid zone by two wavy lines which pass round the globe north and south of the equator through places with an average temperature of 68° F Within this torrid zone thus marked will be distributed rather irregularly most of the intolerably hot places of the world, such as Muscat, in the Persian Gulf, where the temperature may rise to 120° F and keep above 100° all night, so that "the sleepers during the night are watered, like plants, with a water-pot", and such as Murzuk, where 133 25° F has been twice registered

We may mark off a temperate zone south and north of the torrid zone, bounded north and south by lines passing through places with an average temperature of 32° F ; and within this zone we shall find that extremes of heat and cold are rare, though Biskra may run up to 136° F occasionally, and some places in the United States, like Death Valley, in Southern California, may boast now and then of 120° or even 128° in the shade. North and south of the temperate zones we may place the north and south frigid zones respectively; and within these zones we shall find most of the abnormally low temperatures of the world, such as the — 73° F. recorded by Nares, and the — 62° F recorded by Parry.

Differences of temperature noted on the same lines of latitude

Modern meteorologists have extended the principle of this division. They have drawn numerous lines round the globe through places having the same mean annual temperature — the same mean summer, mean winter, mean monthly temperature, and so on These lines are known as "isotherms", and show the distribution of temperature in a clear, diagrammatic way. Thus collated, we see that the warmest places on the globe lie on a line north of the equator, the reason for this being chiefly that there is more sea in the southern hemisphere, and that sea, as we have said, mitigates temperatures. Thus collated, we see, too, that temperatures by no means follow lines of latitude. The Lofoten Islands, Norway, and Verkhoyansk, Siberia, lie in the same latitude, yet their temperatures diverge to an extraordinary degree. The mean temperature of the Lofoten Islands is 40° F.; at Verkhoyansk it is 0° F. The mean January temperature of Verkhoyansk is — 61° F (and the very low temperature of — 89° F has been recorded there), the mean January temperature of the Lofoten Islands is about 32° F, a difference of 93° F. Again, in July, the north of Norway, the middle of England, the middle of Siberia, and Alaska all lie on the same isotherm of 60° F., while in January the Shetland Islands and the south of France are on the same isotherm of 40° F. In January, some of our northern states are on the same isotherm as Iceland; in July, the same states are on the same isotherm as Algiers In January, Lake Superior is on the same isotherm as Greenland; in July it is on the same isotherm as central France.

The important effect on climate of moisture in the air

So far we have spoken almost entirely of temperature, but temperature is only one feature, though perhaps the most important feature, of climate From the physiological standpoint many other features of climate must be considered. Humidity, rain, wind, atmospheric pressure, have each physiological values, not only with reference to temperature, but on their own merits. Physiologically regarded, a mean annual temperature of 80° F on the Karoo, in South Africa, and 80° F. in the Red Sea, are very different things; and likewise a mean annual temperature of 40° at Davos, Switzerland, and a mean annual temperature of 40° in Newfoundland, are very different things Conduction, convection, evaporation, radiation of heat from the body, are all largely determined by the moisture in the air, and a temperature harmless in dry air may be fatal in air saturated with moisture. Heat-apoplexy is always the result of combined heat and humidity.

All meteorological statistics admit the importance of humidity as a factor of climate, and give figures to show the relative humidity and absolute humidity of any place. The United States stretches so far north and south and possesses such a wide variation of surface that average humidity figures would be misleading As we may boast of being one of the hottest and coldest countries in the temperate zone, so we may claim to be one of the driest and wettest. The moisture is very low in parts of Arizona and Texas but it is quite high in southern Louisiana and other Gulf localities.

THE INFLUENCE OF THE WARM KURO SIVO CURRENT — FORT WRANGELL, IN ALASKA

Wind we have already mentioned as a carrier of heat and moisture, but, physiologically speaking, it has climatic value even apart from heat and cold, simply in its essential character as moving air. It is largely because of the movement of the air that seaside places are so bracing, and largely because of the stillness of the air that muggy weather is so depressing. Quite recently, physiologists have shown that if the air be kept in motion a much larger excess of carbon dioxide can be tolerated than if the air be still.

Air-pressure, too, is of climatic importance, not only in respect to the action of the atmosphere in hindering the passage of solar rays, but in respect to its effects on the respiratory and circulatory systems Though, within considerable limits, alteration in atmospheric pressure can be easily met by the compensatory mechanisms of the body, yet health and vigor are affected by the matter of air pressure, and the height of any place must be borne in mind in considering its climatic qualities.

All together, climate is a very complex conception, and a geographical division of climates is almost impossible, for climate is a function of geographical position only in a very broad way.

Is the climate of the earth stable, or is it subject to revolutionary changes? Within the memory of man, local physical changes have produced local climatic changes. But for the last two thousand years, at least, the general climate of the world has been what it is now; and, so far as we can see, the same climate will go on for thousands of years, unless man himself finds some way of altering it. Nevertheless, seeing that there were once jungles and forests at the poles, and that ice covered the northern United States, and seeing, too, that we do not know the cause of these great climatic variations, it were well not to be too certain that the climate of the world as we now know it may not more or less suddenly undergo great and extensive alterations.

THE CHILD'S LURKING FOE

The New Knowledge About the Beginnings of Consumption, Its Detection and Prevention

RAIDING TUBERCULOSIS IN ITS HAUNTS

IN the last chapter of this section we reviewed the chief facts of the existence of the enemy of man which we call the tubercle bacillus. We saw something of its distribution in nature; observed the fact of our ignorance regarding its possible evolution, at any time, from a merely saprophytic bacillus; came to the conclusion that our problem is also the problem of the bovine species, which cannot be solved for us unless at the same time we solve it for them, and ended with the opinion that, whatever be the facts of variation in natural, genetic, inherited susceptibility to the attacks of this parasite, there are also other factors, of unquestionable importance, with which it is our bounden duty to deal.

The observations of the English Royal Commission on the infection of human beings by the bovine form of the tubercle bacillus are a valuable contribution to the subject, but they only confirm what had long been assumed. If the student of tuberculosis were asked what was the most important new fact discovered regarding the disease in the present century, he would certainly name our new knowledge of its existence *in childhood*. On this matter we had hitherto entirely erred. It is a foremost fact, because the problem of conquering the disease really turns upon it; and no writer on the subject is doing his duty who does not insist upon this, the most important and most neglected fact of the disease.

Generally speaking, children are more susceptible than adults to infection. They suffer and recover, and are thereafter more or less immune, as in the case of measles or chicken-pox. Those infectious diseases that we do not associate especially with childhood are to be looked upon as exceptions. Sometimes the exception proves the rule, as in the case of smallpox, which is not now thought of as a disease of infancy and the years which immediately succeed it, but which was so considered before the introduction of vaccination, and is so considered still in an unvaccinated population. Tuberculosis has always been looked upon as a real exception. Less than a generation ago, the universal teaching in medical schools was that this is a disease of early maturity especially, that it attacks the worker in his twenties, and is the characteristic disease of that period. Expectation and analogy would suggest the great unlikelihood of an infection being better resisted by children than by young adults. That is just the reverse of our experience in so many other cases And now the real facts have come to light.

Tuberculosis is commonly a very chronic disease It often runs a course of many years, and until recently it was only during the latter part of its course that it could be readily detected. The tubercle bacillus alone makes very slow ravages. The downward progress of the case is apparent, very often, only when other parasites join the tubercle bacillus, and the patient becomes the victim of a mixture of infections. Hence it is that the earlier stages of the disease have been until lately almost unrecognized. In early adult life, under the strain of hard and confined work, or in association with child-bearing, the patient has come to the doctor with symptoms, and it is presumed that the infection is as recent

as the appearance of the symptoms. That is far from the fact. Often doctors have observed in the adult certain types of physique, shape of chest, fineness of hair, etc., which were supposed to be typical of the kind of person specially liable to be attacked. It seems not to have occurred to us that possibly these features may be the result of a long, slow, insidious process, which was gradually wearing the patient down, and producing these apparent marks of natural delicacy in the patient's physique.

Need for recognizing the presence of the tubercle bacillus at the earliest moment

The reports that, on really careful inquiry, signs of early tuberculosis could be detected not infrequently in children gradually increased in number. Then it was seen that a new examination of the child population was necessary from this point of view, with the aid of the most delicate and exact methods of diagnosis The old days of diagnosing tuberculosis by means of tapping the chest and listening to the sounds produced within it are gone forever from the realm of science Such methods have their constant uses in the observation of a recognized case, but as means of saying whether the tubercle bacillus is actually present they are utterly crude, and the information they can afford is tragically belated A stage in advance of that depended upon the identification of the tubercle bacillus in the sputum, or expectoration, of the patient. That method was of immense service, and always will be so, but we must look upon it as entirely superseded by modern standards of diagnosis. Our business in this disease, from the national point of view, is to identify *every case* at the earliest possible stage, and to have *no untreated case* in the community.

New methods, thanks to Röntgen rays and tuberculin test, make possible this need

Once we understand that this disease is an infection, and think of it as we would think of plague or cholera, we recognize the necessity of realizing this ideal. We must therefore employ the most delicate and accurate methods possible for identifying the presence of the bacillus, even long before symptoms appear, and not least before the bacillus begins to be discharged in millions from the body of its host, for that means that all our work will have to be indefinitely continued. We want the cases which show no symptoms, because then we can do more for them than at any later stage; and we want the cases from which no tubercle bacilli can be obtained, so that such patients shall either be cured and never discharge bacilli, or so that, if that discharge must happen, others shall be protected.

Fortunately, the advance of science has made possible what we need. The two methods must only briefly be referred to before we proceed to note the results they have attained, and to demand that they shall be applied on a national scale, at any rate as soon as their utility and safety are beyond question The first method is the use of the Röntgen rays by the newest apparatus. According to those who have had opportunities of judging, the shadows of thickening round the air-vessels of the lungs, due to the tubercle bacillus, can now be positively detected at stages when no certain symptoms appear, when the ordinary methods of physical examination reveal nothing, and when no tubercle bacilli are being expectorated. Secondly, there are the subtle methods of diagnosis which depend upon the same principle as the "tuberculin test" for suspected cattle.

Tuberculin is a preparation of the poisonous substance produced by the tubercle bacillus and is obtained by filtering and concentrating a certain culture medium in which the bacilli have been grown or by making an extract of the bodies of the bacilli themselves. However prepared, the tuberculin, which is in all cases entirely free from living bacilli, has the property of producing certain well-defined reactions when a small quantity of it is injected into the body of a tuberculous animal, but when a like quantity is injected into the body of a healthy animal no such disturbances are produced. In his investigations of the properties of tuberculin Von Pirquet found that if an application of it is made upon an abraded spot of the skin of an infant, a characteristic local reaction occurs at this

spot in case the child is tuberculous, but if the infant is healthy, either no reaction or only a very slight one occurs. Calmette made use of this same principle of local reaction but applied it in a different manner. He obtained a water-soluble preparation of tuberculin which he used in the eye by dropping it on the inner surface of the eyelid If the subject to whom this test is applied is healthy, no reaction follows, but if the individual is one with active tuberculosis, this treatment produces general congestion of the conjunctiva, as the covering of the white of the eye and inner surface of the lids is called This test for incipient tuberculosis is considered the most accurate so far discovered.

Startling revelations as to the number of infected children

The results of careful examination of children on such lines, in many parts of the world, have been extremely striking, and place an entirely new aspect upon the practical problem of tuberculosis The percentage of children found to be infected has steadily risen as methods have improved, and a large series of post-mortem examinations have established the facts beyond question The result shows that tuberculosis is primarily a disease of childhood. From data obtained by tuberculin tests it has been shown that over 90 per cent of all children are tuberculous in some degree before they reach the age of twelve years. If the entire population, including both those in the country and those in the cities, is considered, it is estimated that from 50 to 70 per cent are infected in some measure by the bacillus of tuberculosis. Probably the essential infection habitually occurs in childhood Some of those infected die as children. Some begin to suffer obviously only in early adult life, while the greater number conquer the bacillus, and live, to die of something else.

In dealing with the question of tuberculosis in childhood it is imperative that we take into consideration the methods whereby infection of the child is usually brought about. There are three ways in which the infecting bacillus of tuberculosis gains lodgment in the body of the child.

How infection by the bacillus of tuberculosis is usually brought about

The first of these is through the air The bacillus coughed into the air by one individual may be drawn with the air directly into the respiratory tract of another, or the bacilli adhering to particles of dust floating in the atmosphere may, in the act of respiration, lodge on the moist mucous lining of the respiratory organs Under such circumstances these bacilli may make their attack either on the inner surface of the bronchial tubes, the adenoid region or on the tonsils, and from any one of these areas the infection may spread to the lungs.

The second method of infection is through the mouth, the most common occurrence of which is, perhaps, through the use of raw milk from tuberculous cows. Also small children when just old enough to creep or toddle about the room have the pernicious habit of putting not only their dirty fingers into their mouths, but also pretty much everything else they can get their hands upon In this fashion bacilli, taken into the mouth, make their way to the stomach and intestines and thence to the lymph-channels through which they are carried to the spine, the joints and other parts of the body. The third is by direct contact, in which the bacillus gains entrance through some cut, scratch or abrasion of the skin as the child crawls over the floor or plays about the rooms whose floors and contents are contaminated with virulent bacilli from some "open" case of tuberculosis

To many, perhaps to most, well-informed people this discussion of tubercular infection among children may come as a surprise, so unfamiliar are we with the idea that the infected child is the forerunner of the consumptive adult. We have all along been taking it for granted that tuberculosis is a disease of adult life, that the consumptive child is a rarity, an accident so infrequent that it possesses no significance. Although it may be true that the number of children suffering from active cases of tuberculosis is not great, nevertheless the number that are infected with the bacillus of tuberculosis, as shown by recent investi-

gations, is much greater than the number that is wholly free from such infection This is particularly true of children living in the crowded and congested quarters of our larger cities, and this fact must be borne in mind in all our national and concerted efforts for the control of this insidious disease.

Report of the presence of the disease the first step necessary

Already we have discussed the question of the cow and its milk. But now we are faced with the problem of the human population infected with tuberculosis These patients, children and adults, are important in themselves, for there must be at least thousands of them showing symptoms in this country at any time, and a far larger number in whom no symptoms yet appear; and they are also important, because some of them are actually spreading the bacillus, for the infection of their neighbors, and because the rest may begin to do so at some future date unless we somehow interfere Given these circumstances, what is the rational course to pursue?

Evidently the first thing to be insisted upon is a prompt report of every case of the disease When a new or unfamiliar malady, such as infantile paralysis, of which we had an epidemic several years ago, makes its appearance in a community the public is thrown into a panic. Every case of the disease, and every other case that even remotely resembles the disease, is promptly reported to the public health authorities; stringent quarantine measures are adopted and strictly enforced, and all agencies earnestly coöperate in the effort to stamp out the malady Everyone seems to realize the danger of this disease an attack of which is very likely to end in death or, what is worse, to leave the victim crippled and deformed for life Yet, as conditions prevail in the United States today, for every victim attacked by infantile paralysis, deaths due to tuberculosis are numbered by scores. If such conditions are not to continue we must employ in our campaign against tuberculosis the same measure of thoroughness that we use against other infectious diseases whose ravages, though more startling and spectacular than those of tuberculosis, are far less serious in the ultimate consequences

Our knowledge of the real nature of tuberculosis renders it necessary that we demand something more than that only the evident cases of the disease shall be reported. All the foregoing discussion has been worth very little if the reader is still unconvinced that our demand that *all tuberculosis* be reported is based upon scientific grounds. Thorough study of the tubercle bacillus has given us the true conception of all forms of tuberculosis as really one, and we see that the problem is to deal with that bacillus, irrelevantly of whether it happens to be attacking the lungs, or the glands in the neck (whence it may very soon reach the lungs), or any other part of the body

The ideal, to the attainment of which we must devote all our energy, is that every case of the disease in the community shall be known and treated. Therefore every case must be reported.

The non-infectious nature of some forms of tuberculosis

If we be asked why pulmonary consumption should be reported, the first and most urgent reply is that the disease is infectious, and we want to protect other people, just as in the case of other infections. There are many other reasons, quite sufficient in themselves, as that, if a certain block of buildings is a plague-spot, and infects all its inhabitants, or nearly all, in succession, we want to identify it, and either pull it down or disinfect it, but certainly the primary reason for the report of pulmonary consumption is that this is liable to be the infectious form of the disease Now, the case of consumption, or tuberculosis, elsewhere than in the lungs, is somewhat different. A tuberculous knee-joint is not infectious, because there is usually no outlet for the bacilli; and even if there be, the risk of infection of others is very small. The grounds, therefore, on which the modern student of national life and health demands that all forms of tuberculosis be reported must be stated.

First, every case whatsoever should be reported in order that, if necessary, steps may be taken to insure its proper treatment. This may or may not rank as charity, it is certainly public expediency The patient must be treated because of what it may mean for others. Every case of tuberculosis, of whatever form, may some day develop into one of pulmonary tuberculosis by spreading to the lungs. It may be, perhaps, that a joint is affected by the bovine form of the bacillus, but that form of the bacillus may be found in the lungs in pulmonary tuberculosis. Therefore a report of the case applies here, just as in one of pulmonary tuberculosis; and it is much more likely than in the latter to be effective before anyone else has yet been infected

Second, as the reader of the last chapter will see at once, we must have all forms of tuberculosis reported, because we must discover where and whence deadly milk is being supplied to the community So long as we report only pulmonary tuberculosis, which is mainly due to human infection, we are dealing with only half the problem.

The varying carefulness of different cities with respect to infection

We must find exactly where the disease from the cow is being planted in children, and we must then proceed to deal with the source of the infection It is probable that, if report of all forms of tuberculosis were now obligatory, some startling and significant facts would at once come to light. Many towns are particular as regards their milk supply, while others have no effective by-laws. The consequence is that milk that is rejected by the health authorities of one community may be shipped to another. We must ascertain what is the distribution of the forms of tuberculosis due to infection by the bovine bacillus, and we must then act accordingly, with energy and promptitude.

It is therefore here laid down that the first step towards a really national, rational and efficient campaign against tuberculosis is to make obligatory the report of all forms of this disease In logic and in practice this should precede the expenditure of money upon any measures for cure; it involves no cost worth naming, nor has it any other objection It requires only a sufficient extension of "popular science" in order that its reasonableness may be seen, and then it will be done. Administrators wait only for that, and then they will do what they well know to be necessary.

If report of all cases of tuberculosis is to be the first and most important line of attack, how are we to attain that end? Obviously the first step, as we have just pointed out, is the enactment and enforcement of laws making it obligatory upon all members of the medical profession to report all cases of tuberculosis discovered among their patients. In some states these measures have already been adopted and they should be adopted by all. But this, though good in itself and a very necessary part of the plan of attack, is not sufficient; for by this means we should discover only those cases in which for some cause the patient found it advisable to consult a physician. If all cases are to be reported, all must first be discovered and if this end is to be attained, more searching, more far-reaching means must be employed.

The first of these should be compulsory medical examination of all the children in our schools, particularly those in the primary grades, and this examination should extend to all schools, public or otherwise. In our large cities no pupil may enter the public schools without a certificate showing successful vaccination for smallpox, a measure of which all right-minded people approve; but in how many of our cities and smaller communities are the children in the schools examined to discover what proportion of them are infected with the bacillus of tuberculosis? This practice of medical examination of school children, which is strongly advocated by our National Tuberculosis Association and the state and municipal societies affiliated with it, already prevails in some parts of the United States and the practice should be made universal. By following up the cases thus discovered, the sources and centers of infection can be located and dealt with as the circumstances in the various cases may demand.

But the age of infection in childhood does not begin with the school age; that we now know positively begins with birth Statistics show that, with very few exceptions, so few in fact that they may be considered negligible, children are born free from infection During the first year of life they will probably escape the danger of infection with the bovine form of the bacillus; but a child born in a family in which there is a case of open tuberculosis can scarcely hope to escape infection in such surroundings, and it usually occurs long before the school age is attained. How then are we to reach these children of pre-school age? Manifestly it cannot be done through compulsory legislation. If it is to be done at all, it must be done through a campaign of education, and the two most promising factors available in such a campaign are the clinic and the dispensary.

How the clinic can be made a big factor in a campaign of education

The object of the clinic is twofold: first, to arouse universal public interest in the question of tuberculosis and impart information concerning the disease in the community which the clinic is to serve; and second, to find out who in that community are victims of tuberculous infection and advise them as to the proper course to pursue In order to have a successful clinic it is necessary first of all to obtain the services of a number of tuberculosis experts and to find suitable rooms in which the work of examination can be done. But even with these provided, the clinic will be a failure unless the time, the place and the purpose of the clinic have been so well advertised and the public interest so thoroughly aroused that the people will present themselves and their children in the largest possible numbers for examination. It follows, therefore, that the degree of success of a clinic in any community will depend in large measure upon the degree of coöperation given to those in charge of it by the local health authorities, members of the medical profession and others interested in public health and community welfare.

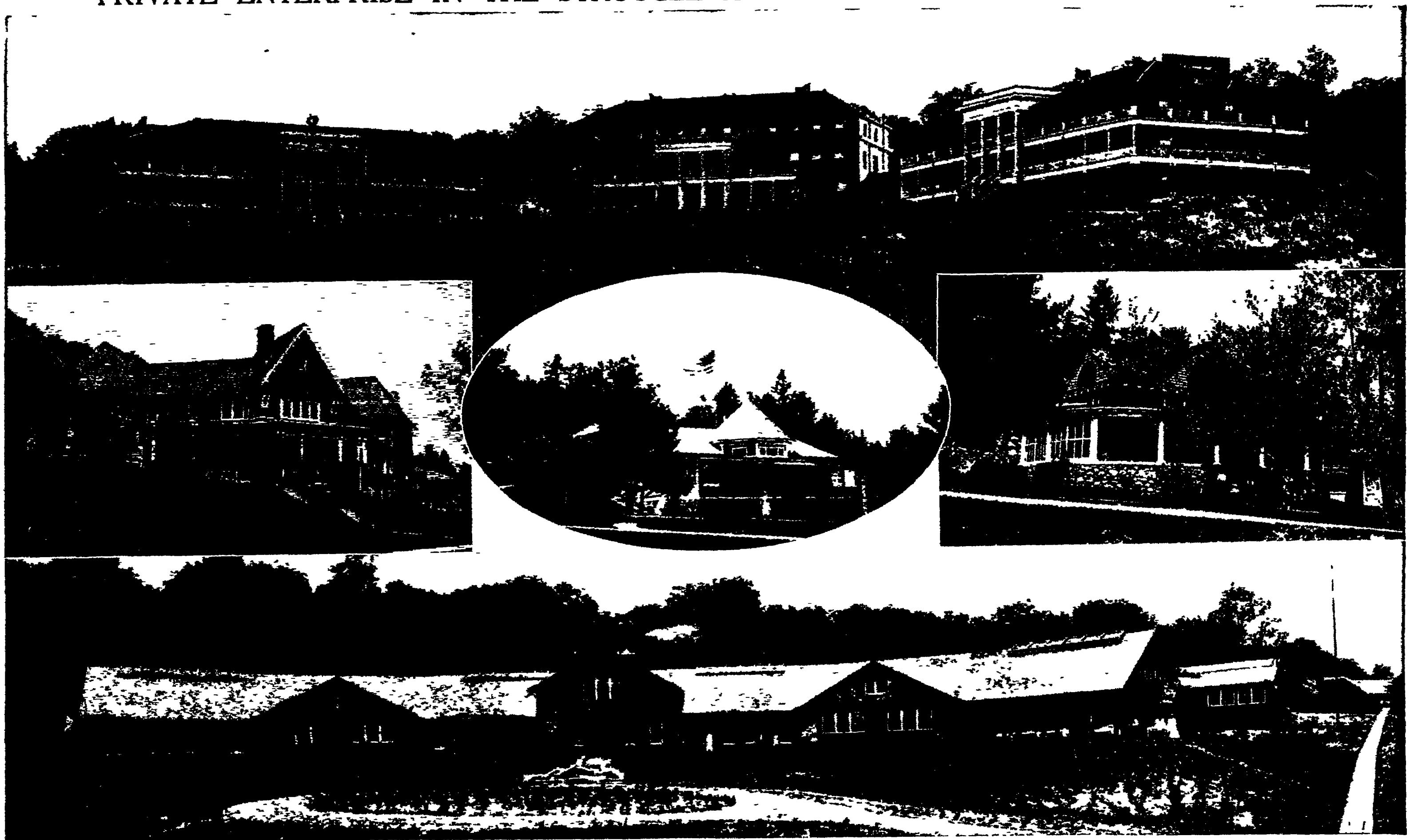
The dispensary should carry on the work, becoming a sort of continuous clinic

These clinics are already in operation in our large cities, and in many states they are rapidly being extended to the smaller towns and even to rural communities

In the same class with the clinic is the dispensary, which may be regarded as a permanent, continuous clinic. The two differ in that the clinic is held in any community only at intervals and its main object is to arouse in the people of the community interest in the problem of maintaining public health, to acquaint them with the infectious nature of tuberculosis, to discover as many as possible of the cases of infection, and to advise those infected as to the best measures to pursue to guard against disaster. Examinations are free, open to all the public, and are publicly conducted It is in fact a campaign of publicity. The dispensary is permanent; it follows up and continues what the clinic began. Its services, too, are open to the public and are, or should be, free of charge. It is not the aim of a tuberculosis dispensary to provide treatment for cases; its function is to conduct examinations, to impart information, to give advice as to treatment of discovered cases, and to guide and direct those who have wholly or in part "recovered" from an attack of the disease. One or more of these should be maintained at public expense in every large municipality, and at least one in every county in the United States.

If the work of the clinic and the dispensary is to result in the fullest measure of service to the community adequate facilities must be available for the care and treatment of the many cases of tuberculosis discovered through their means. It is in this connection that the tuberculosis sanatoria and hospitals fill a vital need. Of the institutions of this nature now in operation some are privately maintained and depend upon the patronage of those whose funds are ample; some are maintained by fraternal organizations to care for the afflicted among their members; others are conducted by charitable societies; and still others are wholly or in part supported by

PRIVATE ENTERPRISE IN THE STRUGGLE AGAINST THE WORLD'S GREATEST PEST



GENERAL VIEW OF THE J N. ADAMS TUBERCULOSIS SANITARIUM AT PERRYSBURGH, N. Y. (Photo Geo G Hare)
THREE OF THE NUMEROUS BUILDINGS OF TRUDEAU SANITARIUM, SARANAC LAKE, N Y (Photo W F Kollecker)
THE CHILDREN'S BUILDING OF THE J. N ADAMS SANITARIUM (Photo Geo G Hare)

public funds. Regardless of the means by which these institutions are maintained, they provide the best facilities for competent care and treatment of those suffering from active cases of the disease, particularly of those in whom the disease has reached the stage in which bacilli are being discharged from the body. Here, in addition to finding himself in surroundings the most favorable that experience and skill can provide, the patient is under constant supervision of competent physicians and in charge of nurses especially trained to care for sufferers from tuberculosis In their hands, the patients receive not only the proper medical treatment and direction in those matters essential to their recovery, but they are also instructed as to the mode of living they must observe and the care they must exercise after they have been discharged from the institution if they hope to avoid a recurrence of their affliction. Unhappily too many for one reason or another leave the sanatorium or hospital before the condition of their convalescence warrants their discharge and also all too many, after they have been discharged, disregard all advice and instructions and return to their old haunts and habits of life. Patients that act in this fashion can hope for very little aid toward recovery from sanatorium treatment or from any other kind, for that matter.

The vital need of sanitaria and tuberculosis hospitals, and the rôle they play

Not all those that go, or should go, to sanatoria or hospitals for the tuberculous will recover. When we take into consideration the proportion of the patients in such institutions who, at the time of their admission are in an advanced stage of the disease, we cannot hope for a high percentage of recoveries. But it is in caring for just these very patients, whose recovery is hopeless, that sanatoria and tuberculosis hospitals render their greatest service to the public in the war on this disease; for they thus segregate and confine those who are actively discharging bacilli and who would otherwise be scattered about through the community, and serving as centers of infection and menacing all who came in contact with them If these institutions for the care and treatment of the tuberculous did no more than simply care for these hopeless victims of the disease and prevent them from spreading infection to others, they would amply justify the expense of their maintenance.

The Framingham Demonstration, a community effort toward control of disease

From what we have learned of the infectious nature of the disease and of the measures either now in force or proposed for checking its ravages, it becomes apparent that the problem involved is essentially a community problem. All efforts for the control of this disease, either state or national, will in the end depend for success upon the success attained by the coördinated efforts of the various agencies in the individual communities that together comprise the commonwealth. It was with the idea of testing out the efficiency of coöperative and coördinated activity that the National Tuberculosis Association, aided by funds contributed by the Metropolitan Life Insurance Company, undertook what is known as the "Framingham Demonstration", which is in reality an experiment in united community effort toward control of disease with special stress laid on the problem of tuberculosis. The purpose of this experiment is briefly set forth by Dr. D. B Armstrong in his report on the progress of the experiment, published in the *American Review of Tuberculosis*, 1921:

"It will be remembered that Framingham, Massachusetts, was chosen for this demonstration because it was a representative American community of approximately 16,000 people, typical in most respects of American industrial, living and social conditions There was here also a promise of sufficient local coöperation to justify the success of the practical service aspects of the Demonstration program — an assurance which has been generously substantiated by experience. The objects of the Demonstration were essentially to bring under observation all of the tuberculosis in the community, to apply the best-known methods of treatment, to develop a

comprehensive program of prevention and to organize most effectively the varied resources of the community for tuberculosis control, disease-prevention and health-creation"

This experiment, which was begun in 1917 and is still in progress, is perhaps the most thorough that has thus far been undertaken. Included in its activities has been a thorough investigation and continued study of all things and of all conditions affecting in any way the health of the community: school, factory and civic sanitary conditions; milk and food control; expert medical examination of practically the entire population; Von Pirquet tuberculin survey of children; establishment of consultation and clinic service; summer camps for children; and other means for reaching and caring for those with impaired health. It also aided in expanding and rendering more efficient the various local health services, which have from the beginning coöperated to their fullest extent with the Demonstration and to which more responsibility is progressively being intrusted as the experiment proceeds. Although the work is still incomplete and the results undetermined, some things have been shown that may be of interest here. The examination of thousands of the people of Framingham, including men, women and children, showed that approximately one per cent of the population were suffering from cases of *active tuberculosis*. This would indicate that in a city of 100,000 we should probably find *1000 cases of active disease*. When this experiment started statistics available showed that for each annual death from tuberculosis in the community there were three known cases of the disease. But the results of the careful and thorough examinations conducted showed that instead of the ratio being three active cases of the disease to one annual death the ratio was *nine or ten* active cases to one annual death. The discovery of this ratio, which is called the "Framingham yardstick", emphasizes what has already been said, and in the words of Dr. Armstrong it "indicates that the 'next step' in tuberculosis work is the *first step*, namely, the discovery of the disease". Before the Demonstration, of all the cases reported in Framingham 45 per cent were in an early stage. Of all the cases coming under observation since the Demonstration started 83 per cent have been found in an early stage, in which hope of recovery may be entertained. What conclusions will be reached as the results of this Demonstration at Framingham cannot, of course, be known until the experiment has been completed, but the following statement taken from Dr. Armstrong's report of the progress of the work in four years shows that the work is going to go a long way toward finding a solution for the problem of control of tuberculosis:

The results of the first four years of the Framingham Demonstration Experiment

"Tuberculosis as a cause of illness in Framingham is apparently being brought under control. This is particularly true as reflected in the decreasing number of advanced cases. As to mortality, it may be stated that the tuberculosis death rate per hundred thousand, corrected for certification and residence errors, for the decade preceding the Demonstration was 121.5. For the entire Demonstration period thus far, with similar corrections, including the rate for 1920, the figure is 84.2 per hundred thousand — a reduction of about one-third. For 1920 the rate was 64.5 per hundred thousand — a reduction of about one-half under the pre-Demonstration rate after four years of intensive work."

Features of the tuberculosis situation with which everyone should be familiar

Now, in order to direct attention to the seriousness of the tuberculosis situation, we believe it will be worth while to point out some features of the problem with which every one should be familiar. Statistics show that of all who die between the ages of fifteen and sixty, one out of every three die of tuberculosis; and of those who die between the ages of twenty and fifty, one out of every four is claimed by tuberculosis. Of all the deaths that occur at any age one out of every ten is due to this disease. What is the explanation of the high death-rate from this disease? It is quite simple:

tuberculosis is an infectious disease, and the measures employed at present to check the spread of infection are inadequate. While it is undoubtedly true that infection is more liable to occur in childhood than at any other age, nevertheless, no one, either young or old, can consider himself immune to infection by the bacillus of tuberculosis It does not follow that because we have so far escaped an active attack of the disease, we have therefore escaped infection Infection does not signify suffering or sickness The majority of those infected do not develop the disease because the body of a vigorous individual living a wholesome life in wholesome surroundings possesses powers of resistance that enables it to overcome the invading bacilli and imprison them and so render them harmless But we should never forget that these imprisoned and harmless bacilli in the tissues of the body are not dead, and any serious lowering of these powers of resistance, whether brought about by worry or overwork, by unsanitary conditions in home or factory, by a life of dissipation, or by influenza, typhoid fever or some other disease, may liberate them and provide a fertile field for their deadly work.

Another thing to be remembered is that there is, so far as we know today, *no cure for tuberculosis* This disease is caused by the invasion of the body by a parasitic organism, and there are no means known by which all these invading bacilli, once they obtain a foothold, can be killed or driven out. A patient may, and very frequently does, recover. In fact, if the case is discovered early enough and the proper measures for combating the disease adopted, there is no reason why he should not. But recovery does not mean cure; for his foe is still with him, ready to strike whenever a suitable opportunity presents itself.

From this it follows that emphasis must be laid at all times upon the necessity of guarding against conditions and circumstances that lead to infection. Since the tubercle bacillus is quickly killed when exposed to sunlight, infection seldom occurs out of doors. Tuberculosis, therefore, is essentially a house disease, and the greatest danger of infection comes from living with ignorant or careless consumptives, especially in dark, damp, poorly ventilated dwellings, shops and factories where everything is soon contaminated with the deadly bacilli through the coughing and indiscriminate spitting of the sufferers

Children should be kept entirely separated from sufferers with active cases of tuberculosis, even if that means separation of children from parents, nay even of the new-born babe from its tuberculous mother. It is to prevent infection as well as to provide the best facilities for recovery that patients with active cases are urged to enter sanatoria for treatment, and it is for this same reason that in some of our cities tuberculous children are segregated in their own schools, open-air schools, where they not only will not infect others but will also be given surroundings that will at the same time best promote their recovery.

Data available for the Registration Area of the United States showed that in 1904, the year in which the National Tuberculosis Association was founded, the annual death rate from tuberculosis per 100,000 of population was 200. In 1921 it had fallen to 99. That is, within a period of seventeen years, during which the war on tuberculosis has annually increased in vigor, in extent and in efficiency, aided no doubt by the advent of better wages, higher standards of living and by prohibition of intoxicants, the death rate from this disease has been cut in half, which means an annual saving to the nation of at least 100,000 lives. Thus, much has already been accomplished; but much yet remains to be done. The results so far attained at Framingham show that the death rate from tuberculosis is entirely too high. The work of this Demonstration also indicates that ultimate success in the control of infection and in the care and treatment of the afflicted will depend upon the coördination of all forces in the community attack. In the words of Dr. Armstrong: "Tuberculosis is not merely a medical problem; it is not merely a health problem; it is a social problem, in the broadest sense, requiring a comprehensive community engineering plan, if the possibilities for disease control are to be realized to the full."

FUNCTIONS OF THE FLOWER

Its Structure and Component Parts, and Their Relation to Each Other in Continuing the Life of the Species

THE ENDLESS MARVELS OF ADAPTATION

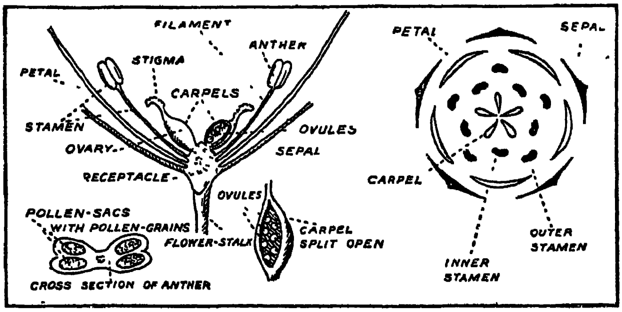
WE are now approaching the conclusion of the consideration of the life of a plant from the point of view of its individuality, though we have yet to consider one or two aspects of plants regarded as societies. So far, we have been mainly concerned in an endeavor to trace out as clearly as possible the varied aspects of the life-history of the plant, and to see what are the different factors which determine the course of the individual plant's existence and constitute its environment. Two products of an individual plant, however, still remain for our consideration, and we have left them purposely until the last because they are the final products for which the plant lives its life. We refer to the flower and the fruit. It is the former which we shall consider in this chapter.

Already we have learned a good deal about flowers in this connection. We have studied how their colors act as a means of attracting animals to them; we observed how the scent of the flowers has a somewhat similar and even more important function. As the result of these attractions we observed the manner in which an entrance is gained to the interior of a flower, and how the creatures who sought to gain that entrance are received there. Something was said as to the taking up of pollen by insects, and its deposition by them, and other means of distribution of pollen were noted in connection with wind and water. All these topics have a more or less direct bearing upon the subject of the flower, but still it remains for us to concentrate our attention upon the structure of the flower itself, its different parts and their functions.

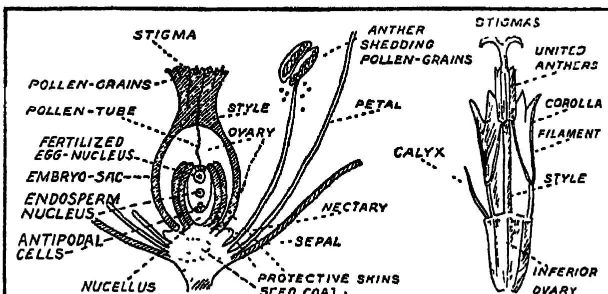
Of all objects in natural science, probably flowers would be universally deemed the most attractive; they certainly afford to our senses the purest of gratifications. Tastes differ about almost everything else in this world, but it is safe to say that there is not a man, woman or child who is not a lover of flowers. It is not, of course, at all necessary to understand a flower in order to love it, any more than it is in the case of a human being, but flowers become of tenfold interest when one realizes all the beauty of their wonderful structure, and the marvelous adaptations for the performance of function which they exhibit.

What is the flower? Perhaps the most condensed definition, from the point of view of the botanist, would be to say that it consists of the organs of reproduction of the plant. These, however infinite in their variety of structure, coloring and arrangement they may be, possess as essential organs, in all cases, the structures termed *stamens* and *pistils*. In addition, however, most of the flowers possess *sepals* and *petals*, so that altogether there are four sets of organs. These are very often arranged in circles, and when all these sets or circles are present in any given flower it is said to be complete. The whole circle of sepals is termed the *calyx*. The petals taken altogether make the *corolla;* and calyx and corolla combined constitute the *perianth*. From the fact that the whole aim and object of the flower itself is ultimately to produce seed, and because this can only be done by the coöperation of the stamens and the pistils, these latter organs are frequently termed the essential organs of a flower.

If we look at a plant with a view to observing where its flowers appear upon it, we shall find that they occupy, with great regularity, one of two positions. They are either in what we have learned to call the *axil* of the leaves, or else they appear as *terminal* buds This would point to the supposition that they are of a similar nature to leaf-buds, and further observation would suggest to us that sepals much resemble leaves In fact, in some cases it is difficult to distinguish the two. If the reader will take the trouble to examine the next example of the white water-lily he sees, he will find that in this plant there is a wonderful series of intermediate stages between petals and stamens, and many other plants show transition effects also. So that the flower is practically a greatly modified and shortened branch, a conclusion we reach, first, because the flower-buds take the same mode of origin as the leaf-buds; secondly, because many intermediate stages are found in the organs of flowers; and thirdly, for another reason not yet mentioned—namely, that in certain flowers the essential organs are found to be replaced by petals, or even green leaves.



THE PLAN OF A PATTERN FLOWER SHOWN IN LONGITUDINAL AND TRANSVERSE SECTION



A SIMPLE FLOWER AND SINGLE FLORET OF A DANDELION IN SECTION

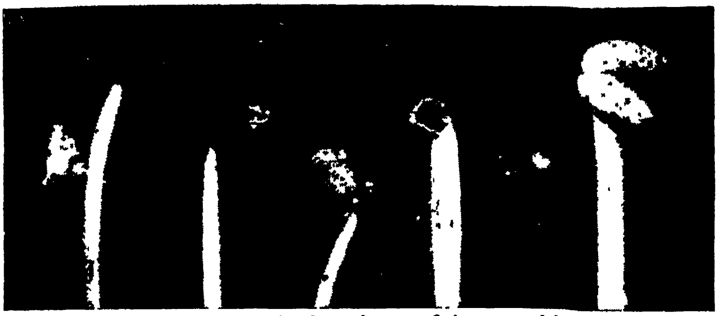
Relationship between a flower and a leaf is further emphasized by the term *floral leaves*, frequently used to express all the parts of the perianth as opposed to the foliage leaves proper. To be sure, the carpels of the pistils and the filaments of the stamens described later are but modified leaves as well, though their relationship is not so obvious as in the parts of the perianth.

We understand now, therefore, that the last and uppermost or innermost leaves modified for production of the mature seeds of a plant together constitute the flower, and the axis on which this is carried is termed the flower-stalk. This stalk may be a direct continuation of the original shoot, in which case the flower is called *terminal;* but much more commonly it appears just above a leaf at one side, producing flowers which are *lateral.* Whatever the arrangement of the flowers may be on a plant, it is quite definite, and is termed an inflorescence. These various inflorescences, or arrangements of flowers on a stem, include the following kinds, amongst others: raceme, catkin, umbel, spike, capitulum or head, panicle, cyme, and so forth, all of which terms will be readily understood by a glance at the examples on page 3724.

We have said that the calyx and the corolla together constitute the perianth, so that in the whole flower we may distinguish (a) perianth leaves (calyx and corolla), (b) stamens, (c) carpels.

The common arrangement of the leaves of the perianth is that of two whorls. The upper or inner of these, which may be the more delicate, is commonly distinguished by the fact that it may exhibit any and every variety of color except that they are not commonly the ordinary green of a leaf. This is the corolla. The lower or outer whorl, which quite frequently apparently

THE FERTILIZING ORGANS OF FLOWERS



This picture, reading from left to right, shows the magnified stamens of the flowers of fuchsia, African lily, tiger lily, garden nasturtium, snapdragon, begonia and foxglove, with the anther sacs fully developed, ready to burst and shed their pollen.

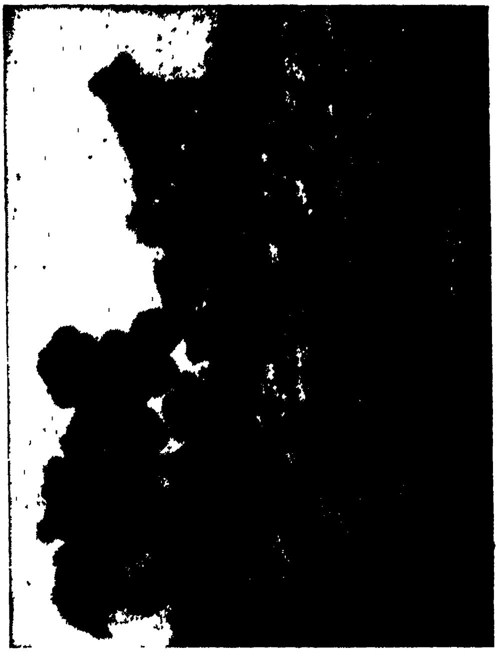
Flower of common chickweed, showing five dark sepals, five white deeply cleft petals, the stamens and three stigmas.

The mouth of a foxglove bell, opened out to show the oval stamens and the projecting stigma. Only the hairy back of a humble bee seeking nectar can brush against these. The spots and hairs within the corolla converge and guide the bee towards the nectary

Thrum-eyed and pin-eyed flowers of the primrose. The former has stamens at the mouth and the stigma midway down the tube; the latter has the stigma at mouth and stamens below. Bees can thus cross-fertilise these plants in two ways.

Female and male flowers of the palm-willow; the female consists of ovary, scale and nectary, the male of two stamens, silky scale and nectary.

consists of green leaves, is the calyx. Occasionally the two whorls look very similar. Next the stamens. These, too, are frequently arranged in whorls. Each stamen consists of two parts, an *anther* and a *filament*. The anther is of supreme importance, because it is that part of the flower in which the pollen is developed. The filament merely supports the anther, it being the sterile part of the stamen.



POLLEN TUBES PENETRATING THE STIGMA

These pollen grains on the stigma of an evening primrose are seen emitting pollen tubes, which penetrate the tissues of the stigma down to the ovary, becoming many times longer than the diameter of the pollen grain from which they arise.

Like the perianth leaves and stamens, the carpels are arranged either in whorls or spirals. In one group of the flowering plants these carpels are like scales, and have their margins quite free and ununited. But in another group the carpels are so compressed together that their margins are completely fused, and when this is the case a structure, called the *pistil*, is formed. This capsule is of very great importance, because part of it is a chamber which is really the *ovary*, and it contains the ovules, which are the rudimentary seeds. It also contains a slender stalk, or style, at the top of which there is a modification, frequently a knob, the stigma. So that the pistil consists of ovary, style and stigma (see diagram). It may be mentioned here, to clear our ideas on the subject, that eventually the ovary will become transformed into the fruit or at least a part of the fruit.

Ovule means "little egg", and was applied to the structures which develop into seeds possibly because it was thought they were similar in structure and function to the eggs of animals If it is necessary to compare ovules with the eggs of animals, one would have to say that the ovules correspond to the animal egg plus a portion of the female parent.

It is a great deal easier, however, to compare them with the already described stamens. The ovules are the fertile part of the pistils just as the anthers are the fertile part of the stamens. The sterile part of the stamens are the filaments and the sterile part of the pistil is the carpel or carpels The anther of the stamen contains pollen and the ovule originally contains tissue, one cell of which is the egg. The coats of the ovule have an opening, the micropyle or little gate through which the sperm from the pollen passes and results in fertilization. The ovule is attached by a stalk, the funiculus, to an area on the inner surface of the carpel or pistil. This region of attachment is the placenta. The function of the ovary is probably to protect the ovules; that of the style to support the stigma, whose function is to secure pollen grains and maintain them.

Since we have learned that pollen grains are brought to the flower by such varying means and agencies as wind, insects, etc., we shall be prepared to find that the stigmas are correspondingly of great variety. In the plants which receive their pollen by the wind, the stigmas are expanded somewhat like feathers or brushes. In those which receive their pollen from visiting insects, the stigmas consist of knobs, or ridges, against which the insect knocks off its pollen in its movements on entering the flower.

It should also be mentioned before we leave these structural details that the stamens in some cases are quite distinct from each other; in other cases they cohere by their filaments or by their anthers into one or several groups The same is true

of the pistils, which are sometimes distinct from one another, as we see them in the buttercup, and sometimes united to form a compound pistil In this latter case the union of the pistils results in a corresponding structure of the ovary, which is sometimes readily seen if such a cross-section be made of that organ as will show its compartments A compound ovary may show several separate chambers, and in these chambers the ovules may be carried in a very definite line, or position. That line, we have seen, is termed the *placenta*. Where the pistil is compound there will be as many placentæ, or ovule-bearing lines, as there were carpels joined together. In this way we get different types of placentation according to the way in which the ovules are placed, and which are termed respectively parietal, central and free central.

If all the parts of the same set or circle of organs in a flower are alike, the whole flower is then said to be regular, or symmetrical Such flowers are those whose calyx, corolla, stamens and carpels each contain the same number of parts, or a multiple of the smallest number. A flower like the stonecrop is termed symmetrical, it having five sepals, five petals, five carpels and ten stamens; whereas the rose and mignonette are irregular and unsymmetrical, because they have an indefinite number of stamens.

Lastly, in this connection, we must note the fact that there are certain flowers that, from the point of view of structure, are different in some of their parts. That is to say, in some flowers the stamens and the pistils are not found together in one, but in separate flowers, which are therefore said to be imperfect. Note carefully that this imperfection does not apply to the success with which the function of the flower is carried out, but merely means that both kinds of essential organs are not found in the same flower. For example, in the imperfect flower of the willow each flower of the catkin consists merely of a pistil, or group of stamens, plus certain sterile parts.

So much for the morphological aspect of the flower. The foregoing brief account of its structure will be sufficient for our purpose here, taken in conjunction with a careful study of the diagrams and illustrations appended. We may now turn our attention from the structure and position

TRANSITION FORMS FROM PETALS TO STAMENS OF THE WHITE WATER-LILY

of these various floral organs to the functions which are allotted to them in the life-

STAMINATE AND PISTILLATE CATKINS OF THE ALDER TREE

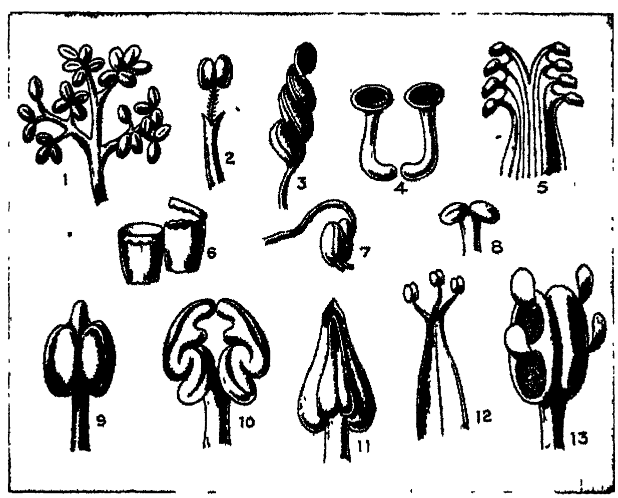
Pollen from the staminate catkins seen above is responsible for the fertilization of the tiny pistillate ones between them The latter become woody cones, like the larger ones below, which have dispersed their seeds Should these seeds alight in a stream they may spread the tree far and wide.

history of the plant, reserving for a later paragraph some special remarks concerning pollen and the varying forms of its grains.

The only two structures actually indispensable for the fertilizing function of the flower are the ovules and the pollen grains. But it is quite obvious that these all-important structures must be also carefully and suitably protected in order that they may do their work. This protection must be given to them during the whole period of their development, as well as during the process of fertilizing. It is not enough that ovules and pollen grains should merely be produced. Neither is it sufficient that, having been produced, they have some measure of protection; there must also be developed adequate means for bringing them together This is frequently attained by an exquisite adaptation in the form of the floral envelope. In fact, we find, on a careful examination of all the different parts of a complete flower, that there is a very perfect division of labor among those parts, constituting another example of that specialization of function we have studied in previous chapters in connection with different parts of the plant organization.

ARRANGEMENTS OF FLOWERS ON THE STEM, SHOWING VARIOUS FORMS OF INFLORESCENCE

1, vervain, spike, 2, cherry, simple umbel, 3, groundsel, composite heads arranged in a cyme, 4, cow-parsnip, compound umbel, 5, lilac, panicle, 6, Yucca gloriosa, panicle, 7, common marigold, composite head, 8, currant, raceme, 9, Arum maculatum, spathe and spadix, 10, walnut, catkin, 11, scarlet pimpernel, solitary



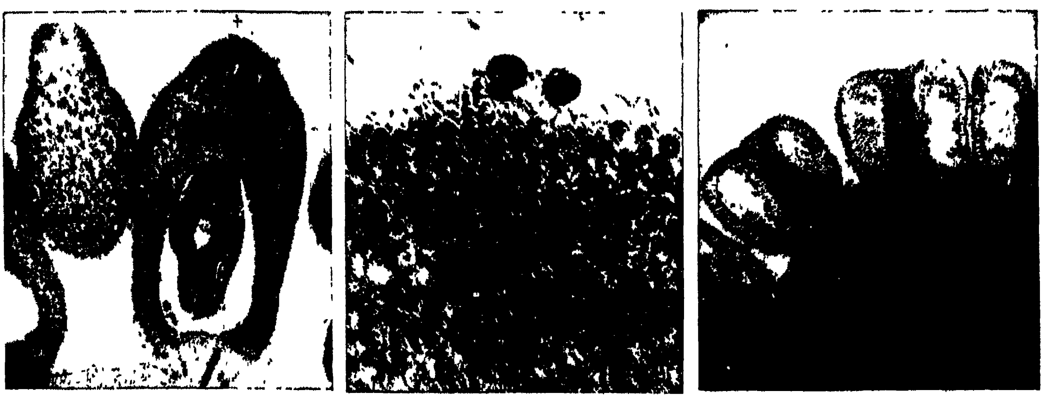
VARIOUS FORMS OF ANTHERS

1, Ricinus; 2, Aconitum napellus; 3, Erythræa centaurium, 4, Pinguicula vulgaris; 5, Polygala amara, 6, Garcinia morella, 7, Pyrola uniflora; 8, Caltha palustris, 9, Juglans regia, 10, Bryonia dioica; 11, Cyclamen europeum; 12, Corydalis capnoides, 13, Litsœa baueri.

Thus we find that sometimes only one part of a flower develops ovules, or pollen — one part secures protection, one part secures fertilization. Sometimes there is a combination of duties allotted to a certain structure, as in those plants in which the carpels not only carry the ovules, but also protect them and convey the pollen to them. In others, such as the primulæ, the ovules are quite independent, so far as dissemination is concerned, being merely surrounded by ten carpels which protect them, and secure pollen, which results in their fertilization. Many plants, several already seen, produce means of attraction for insects, which collect pollen from different flowers and scatter it upon stigmas ready to receive it. But whatever the arrangements may be, and however specialized or combined the functions may appear, all are adapted towards one end—namely, that of fertilization, which is the whole object of the entire flower.

Fertilization in a plant, as in an animal, consists in the union of the essential contents of two separate cells to form a

new and distinct cell, from which latter the embryo of the new plant is destined to spring. A cell from a pollen grain unites with an egg cell at a definite point, known as the apex of the embryo sac, as shown in our diagrammatic representation of the fertilization of an ovule. The new cell which results, therefore, contains material derived from both the pollen cell and the egg cell, just as we have seen in our study of animal development that the embryo results from the union of male and female cell elements In many plants the pollen, in order that it may succeed in its fertilizing mission, must be produced by another plant of the same species — that is to say, from a plant other than that which has produced the eggs that have to be fertilized. The pollen grains themselves — which, as we shall see later, on page 3727, are of various shapes and sorts — are launched, by one or other of the means we have already studied, on the surface of the stigma; and, having been placed, or deposited, there, they proceed to grow in the shapes of tubes, possibly taking some twenty-four hours or more before they begin to do this. The pollen tube so produced has to make its way through the *style* of the ovary, in which the ovules are lying, and this process of penetration will, of course, take a varying length of time, somewhat proportionate to the actual length of the style through which the penetration must take place. Sometimes — as in the case of the "silk" of corn — this style is several inches long, and in such a case the descent of the pollen tube through it will be a matter of several days' performance Such a case is seen in that of the crocus; but whether the time taken be long or short, the pollen tube eventually penetrates the ovule at an opening in the apex, and, growing inwards, ultimately reaches one of the cells within. Here, therefore, takes place the union between the generative cell of the pollen tube and the egg cell of the ovule. The union produces a fertilized germ cell, which, like other cells of this character, then begin to divide again and again, and thus to grow into an embryo



STAGES IN THE POLLINATION OF THE ARUM BERRY

The left-hand picture is a longitudinal section showing two tiny grains of pollen (enlarged in the center picture) resting on the stigma. These grains emit pollen tubes similar to those seen on page 3722, which penetrate and fertilize the egg cells of the ovule in the center. The right-hand picture is a cross-section of some of the stamens, showing pollen grains developing within

It should be noted in passing that the two terms *pollination* and *fertilization* are not necessarily synonymous. Fertilization can only occur in flowering plants after pollination, or the dusting of the stigma with pollen, has taken place. But the important point to remember is that mere pollination does not invariably mean that fertilization must ensue. In spite of pollination taking place, sterility, or the absence of fruit production, may frequently occur, and this may happen for many reasons. The stigma may not be at the proper stage to receive the pollen. The pollen cells themselves may be unable to produce pollen tubes and other factors may intervene.

In order that one ovule may be fertilized, it is only necessary that one pollen tube should reach it. But, owing to the risk

that pollen runs of being lost in the process of transference from flower to flower, it is obviously necessary that many more pollen grains must be produced than there are ovules requiring fertilization. The excess of pollen grains produced varies very much in different plants In one variety of cereus there are no less than 250,000 pollen grains for some 30,000 ovules, or rather more than 8 to 1. In the common garden wistaria there are no less than 7000 pollen grains to every ovule, and a great many plants produce pollen grains in a proportion even many times greater than 7000 to 1. These differences obviously correspond with the manner in which the pollen is transferred from the stamens to the pistil, and the risks of loss involved in that process.

It must not be supposed, however, that any kind of pollen will fertilize all kinds of ovules. We must carefully remember that in this process of fertilization in flowering plants we are dealing with living things, which are to all intents and purposes male and female, and which consist of more or less sharply defined classes, families, orders and species. The possibilities of fertility and reproduction, therefore, are limited very much in the same way as they are in different species of animals, if not quite so strictly. One must suppose that under natural conditions, especially where many flowers and plants are growing in the same neighborhood, or in great clusters, the pollen of many different plants will be deposited on one stigma by one or other of the agencies concerned in pollination. But unless the pollen deposited is of the character and relationship necessary, fertilization will not follow.

In this connection one must not omit to mention a very curious and interesting fact with regard to pollination by insects — namely, that certain insects have been proved to show an extraordinary preference for visiting one single species of plant for quite a considerable time, especially if that plant is in the flowering stage, and in abundance in that district. The advantage of this process for insect fertilization is, of course, obvious. At the same time, if one carefully observes the insects among the flowers, one will soon be convinced that most of them change the flowers visited frequently. Thus, "a bee which has just dusted itself with pollen in the flower of a monk's-hood will fly across to visit a bush of willow, and as it passes a plant of *Daphne Mezereum* it will suck its honey; a moment later it

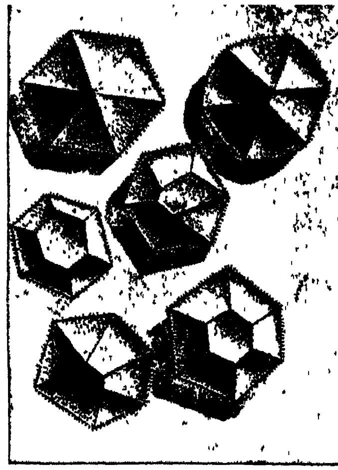
POLLEN GRAINS OF GRASSES CARRIED BY THE WIND TO THE STIGMAS OF THE FEMALE FLOWERS

The left-hand picture shows a branch of quake-grass whose stamens protrude through the scales of the spikelets of the flowers The pollen shaken from the stamens is blown to the stigmas of distant plants of its own species. The right-hand picture shows stigmas of cocksfoot grass receiving pollen grains blown to it by the wind The latter picture is highly magnified.

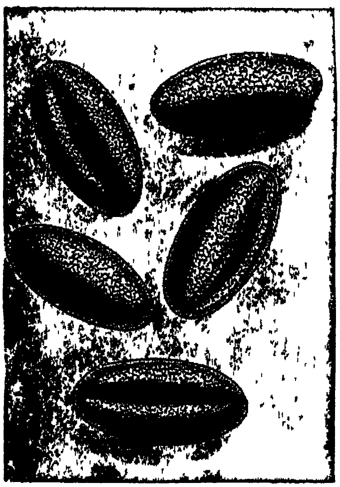
THE VARYING FORMS OF POLLEN GRAINS

RHODODENDRON

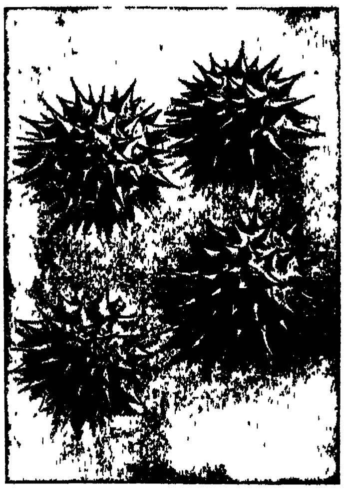
PASSIFLORA CŒRULEA



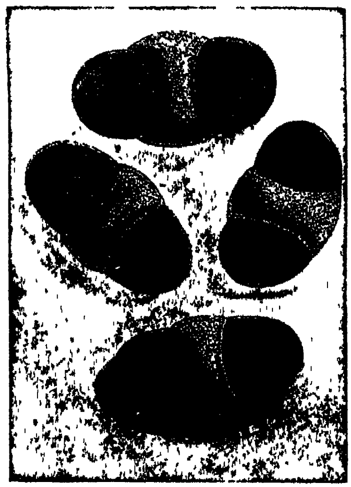
DANDELION



TIGER LILY



MARGUERITE



SCOTCH PINE

CLARKIA ELEGANS

PHLOX

EPILOBIUM AUGUSTIFOLIUM

will swoop down to the flowers of *Crocus* in the meadow near by, and then fly on to some violet. On the stigma of the last-mentioned plant will be found the pollen of all or several of the just-visited flowers, on the crocus that of the willow, and so on. The case is similar with wind-pollinated flowers"

In such a case the pollen of the willow does not fertilize the ovule in the crocus. All that happens to the willow pollen is that it undergoes certain physical changes which are similar if it be placed in any moist material Complete development, however, does not occur In other words, the tubes, if they grow, do not fertilize the eggs in the ovules. Put in another way, one may say that it is part of the function of the stigma in a flower to exercise a capacity of selection of the proper kind of pollen suitable for its own ovule fertilization. How this selection actually is brought about we do not know.

Numbers of experiments have been made upon the point, but all that we can say is that with certain pollen applied to certain stigmas fertilization does, or does not, take place; or that with such and such pollen no seed formation follows, or moderate production of seed follows or great abundance. In fact, all the observations and experiments which have been directed towards ascertaining the general laws which underlie this process have led botanists to conclude that when the pollen from one species of plant reaches, or is put upon, the stigma of another species, such pollen grains produce tubes capable of fertilizing the ovules only when the two species of plant concerned belong to the same natural family of plants. Conversely, pollination between two individuals of different natural orders of plants usually is not followed by fertilization Finally, in this connection, if the pollen from the male flowers of a plant reaches, or be artificially placed upon, the mature stigma of the female flower of that same species, fertilization is practically certain to follow, and result in the production of fertile young. Except when the two parents are of the same species the young would not be expected to be fertile.

The pollen itself, however, as we hinted in an earlier paragraph, deserves some special mention. It is a wonderfully interesting substance, exhibiting many astonishing variations when subjected to careful examination. In many of the flowers which are not at all conspicuous to the eye the pollen is in the form of a fine, dry powder. This is the case in the family of grasses and rushes, and sedges and conifers. In the more elaborately colored flowers the pollen is frequently of a sticky nature. The grains themselves, too, differ extremely in both size and color, as well as in their consistence Some are long and green, some long and yellow, some as broad as long. A very common shape is a somewhat oval grain rather like the shape of a grain of wheat. Our illustrations in-

THE SELF-POLLINATION OF PYROLA UNIFLORA AND GENTIANA CLUSII
The petals have been removed at the dotted lines to show the process.

dicate the various shapes and appearances of a number of pollen grains from a number of species of plants.

Each pollen grain is chiefly made up of a cell covered by a thick outer wall and a thinner inner wall. Within these is contained the protoplasm of the cell itself, and amongst this is frequently found some grains of starch and minute oil globules. On the outer surface of the grain may be seen one or two protuberances, which indicate the position where the inner coat will ultimately emerge through the outer one in the form of the pollen tube. The whole grain, in perhaps quite half of all the flowering plants, is ellipsoid in shape. Others are round, lancet-shaped, biscuit-shaped, angular, three-sided, four-sided, five-sided, six-sided, or cubical.

GETTING READY FOR THE FLOWER SHOW

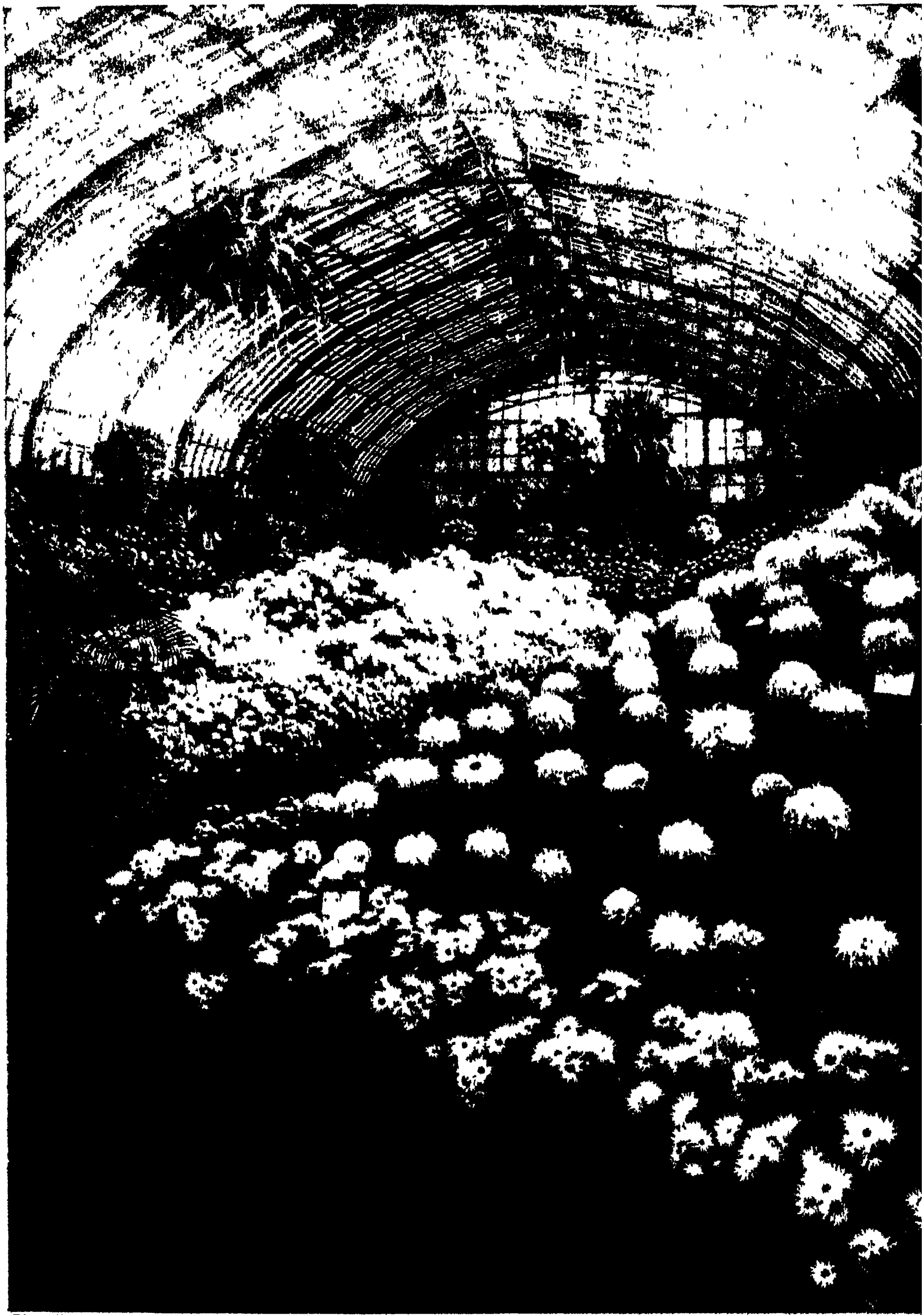
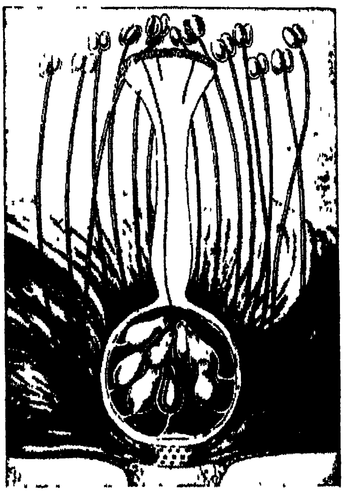


Photo Eugene J Hall

THE INFINITE VARIETY OF THE CHRYSANTHEMUM

The surface of the pollen grain, especially in the ellipsoid and round grains, is generally grooved or marked, and the number of grooves upon the surface is found to be the same in all grains from the same species of plants. In some pollen grains there may be found very small openings in which a yellowish oil is contained. Many species of pollen have such an oily substance over their whole surface. Others stick together by means of an entirely different viscid material, such as is found in the pollen grains of the fuchsias and orchids, in which it can be drawn out into threads.



PICTURE-DIAGRAM SHOWING HOW POLLEN REACHES AN OVULE

There are other structural peculiarities and appearances in pollen grains, but the above will suffice to mention here; and the point now arises, Why all this variety in the formation of pollen grains? What is the object of all the grooves and furrows and projections, and oil and apertures and so forth? We can only answer some of these points in a sentence or two here

When pollen is placed in water, it swells up quickly. Its inner wall must therefore be able to stretch with ease. The folds allow the fluid to pass quickly to the interior, and the grooves become inflated. The pollen grains, so thoroughly moistened, may be several times the original size. All the various inequalities and irregularities on the wall of the pollen grains enable a number of grains to cling together.

In this way an insect is able to transfer large masses of pollen at the same time. The dry pollen of the grasses and other plants — dusty pollen, as it is sometimes called — does not cohere in this way, and so cannot stick so easily. On the other hand, its consistence renders it peculiarly susceptible to the distribution by wind. The capacity of pollen grains to stick together, so that they may easily attach themselves to the hairs, legs, etc., of insects, is of very great importance. The oily and viscid coating of other pollen grains aids in a similar manner.

Lastly, we must briefly refer to self-pollination. In the simplest form, when the flower opens, the stigma is seen in front of the entrance, and already ripe, while the anthers adhere to it, but are closed. At this stage cross-pollination can be brought about. But a little later in the flowering time the anthers next to the stigma open, and the stigma itself is, of course, at once covered by pollen which is set free from them.

It must be said, however, that many cases of self-pollination are much more complicated than this Some are brought about in pendent flowers by the pollen from the anthers falling upon the viscid stigma, as happens in the snowdrops. In many cases the stamens are particularly adapted for the process of self-pollination by the manner of their bending, or by their peculiar movements, as is seen particularly in the stamens which curve inwards. Sometimes self-pollination is brought about by a peculiar bending of the pistil, sometimes by a coiling arrangement of the stamens and the pistil, and sometimes actually by means of the corolla. This latter is seen in those flowers whose petals are cup-shaped, and in which the anthers adhere to the inner surface of the petals, coming in contact with the stigma when the corolla closes.

The fact that all these variations in flower parts and functions of parts occur, should be encouraging rather than discouraging. Only a few of the types are here presented. It is hoped that they have proven sufficiently interesting that you may wish to go to the flowers themselves for further interesting facts.

THEIR MYRIAD WINGS MAKE MERRY MUSIC ON THE MARSH

Photo Herbert K Job

BREEDING COLONY OF ROYAL TERNS ON A LOUISIANA BIRD RESERVATION

OUR COMMON BIRDS VIII

Loons, Grebes, Gulls and Terns, Herons, Geese and Ducks, Rails, Gallinules, Coots, Sandpipers and Plovers

WATER BIRDS

"AS crazy as a loon" is an expression that gains force when one hears the weird notes of one of these curious divers. Beginning low, the strange sonorous sound rises in pitch and increases in volume until it ends with a terrible spasmodic gasp. Heard in the dead of night when one is alone in the silent forest it has the faculty of arousing one from slumber with a stiffened scalp and strange prickly feelings in the vicinity of one's spine. Sometimes a pair of birds will hold a concert, or a single bird will locate a rocky cliff where there is a good echo and will call to himself for hours at a time The notes are then different and resemble more the insane laugh of some escaped maniac. Those who spend their summers in Canada are familiar with the loons and their ways because one cannot camp by the lakes where they nest without being almost continually aware of their presence. Those who do not go to Canada or get into the lake country of northern New England, however, seldom see them or realize that they are present, sometimes in large numbers, on the larger bodies of water and along the sea-coast throughout the United States during the winter. For at such times they are silent and usually keep a safe distance from the shore. On their migrations over land they usually fly high and, because of their large size and long necks, they are sometimes mistaken for geese, but the flocks of loons never assume the characteristic wedge of the wild geese. Though there may be a hundred or more birds in the flock, they seem to care nothing for each other's company but fly in scattered ranks.

During the winter the loons are colored much alike, being grayish above and white below, but during the summer they are quite different. There are but five species of loons in the world, confined to the northern half of the northern hemisphere, and only one of these, the common loon, is often seen. It is black above during the summer, the back spotted with white, and there is a half ring of white streaks on the neck. The underparts are white, but as it is seldom seen except on the water, when the underparts are invisible, the general impression is that of a black bird about the size of a goose but with a shorter neck and a longer bill. The bill is very strong and sharply pointed, for it is used for spearing the fish upon which the loon lives. The fish are usually small but occasionally weigh as much as a pound or even two pounds, when they are swallowed with much difficulty. The fish are pursued by the loon and speared beneath the water, the strong webbed feet of the bird driving it through the water at such speed that the wings are never used unless the bird is wounded. The fish are never swallowed beneath the water, the loon always bringing them to the surface and juggling them around until it can swallow them head foremost.

The loon ordinarily lays its two olive-brown spotted eggs in a mere depression along the shore, on a hummock of mud or a muskrat house where it can quickly slip into the water and dive from sight. The young loons are covered with thick black down when hatched and almost immediately take to the water where they can swim and dive with the greatest ease.

The mysterious grebes

Closely related to the loons but differing from them in many essentials are the grebes or, as they are popularly called, "the hell-divers". There are twenty-five different kinds of grebes (family *Colymbidæ*), found all over the world, and six of them are found in North America. They are all smaller than the loons, being about the size of small ducks, which, indeed, they very much resemble. They can always be distinguished from the ducks, however, by their pointed bills, short rounded wings, and apparent absence of tails, which are represented by mere tufts of feathers. Their feet instead of being fully webbed, as in the ducks and in the loons, are lobed, appearing as though the webbing had been cut between the toes. This does not seem to hinder their swimming or diving, for they are fully the equals of their larger cousins, diving so deep and remaining under for so long that they seem never to come up. Indeed, when alarmed, they sometimes come up very quietly until just their bills show above the water, and if there is a slight ripple on the water, they are entirely invisible. This has given rise to many stories of mysterious disappearances and to such popular names as "waterwitch" and "hell-diver". They either dive head foremost with a flip of their feet, or they settle backwards so carefully as to scarcely leave a ripple on the surface Such expert divers are they that they prefer to rely upon this method of escape rather than to fly, especially as it seems to take so much effort for them to rise. When they do take flight they ordinarily patter along the surface for some distance before they are able to get up enough speed to lift themselves from the water. Once on the wing they look a great deal like ducks, because they carry their feet straight out behind them, and these make up for the absence of a tail, which would otherwise be a conspicuous difference.

LOON

The commonest species of grebe is the pied-billed, an inconspicuous brownish little bird even when in its breeding plumage. It is found most often on reed-bordered ponds and marshy lakes where it builds its floating nest and anchors it to the reeds. The nest is but a pile of débris and looks like the little platforms that muskrats sometimes build to rest on. When the bird leaves the nest she always covers her eggs with some of the material of the nest, and as she is seldom if ever surprised on the nest, it was once thought that the pied-billed grebe did not incubate its eggs like other birds but depended upon the sun and the heat of the decaying vegetation to hatch them. The eggs are white when first laid but soon become discolored. The young grebes, when first hatched, are curious little creatures covered with down and

Photo A. A. Allen

A WATER BABY'S FIRST SWIM
Pied-billed grebe, nest and young

striped black and white very differently from their parents They are able to swim almost as soon as hatched and follow the old birds about the pond When the young get tired, they climb on to the backs of their parents and in case of alarm, the old birds cover them with their wings and dive from sight, coming up among the reeds where they can easily hide. The pied-billed grebes are found in summer from British Columbia to Chile and Argentina, having one of the most extensive breeding ranges of any bird, and in winter from Maryland southward

HERRING GULLS ON THE CITY'S WATERFRONT

The graceful gulls and terns

To those who go down to the sea, there is no bird more familiar than the sea-gull (family *Laridæ*). It matters not that there are fifty different kinds of gulls in the world with as many different names All of the long-winged graceful white birds that follow the ships the world over or congregate in large flocks in the harbors are everywhere called sea-gulls and always will be Absolute masters of the air they seem, for no storm is so severe that they cannot still be seen, now circling high over head, now gliding close to the waves, now sailing apparently straight into the wind without a movement of the wings. Sometimes they sail, for hours at a time, by the stern of the ship, taking advantage of the air currents and never moving their wings except occasionally to alter the angle at which they are held. Again they are seen tossing about on the waves, for they have webbed feet and can swim like ducks.

The majority of gulls are pure white except for a pearl-gray mantle and black tips to the wings, but some have the mantle darker and others have the head black during the summer, while still others have the entire plumage white with scarcely a mark. Immature gulls are darker than the adults, being dusky or grayish and changing gradually through two or three years to the plumage of the old birds.

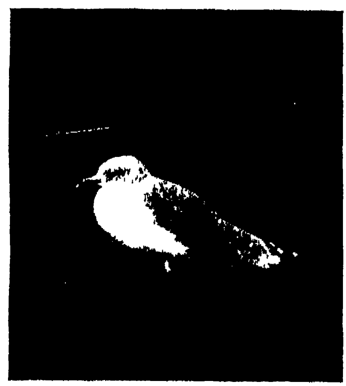
Gulls vary in size from that of a pigeon to that of an eagle, although they are always more slender than the latter. As a group they are larger than the terns, though some of the terns are larger than the smallest gulls. The majority of terns are about the size of slender pigeons but some are not much larger than the largest swallows. Indeed, they are sometimes called "sea-swallows" because of their long pointed wings, deeply forked tails and light airy flight.

Terns do not often sail like the gulls, but few birds excel them for gracefulness. With measured beats of the wings, almost suggestive of the motion of a butterfly, and with their bills directed downward as

they watch the water, they beat back and forth along the coast hunting for small fish. Once a flock of terns locates a school of small fish, a scene of intense animation follows. The light airy flight gives way to a series of daring plunges and they dart from a considerable height into the sea, spearing the small fish with their needle-pointed bills. In this method of feeding they differ entirely from the gulls, which have hooked bills and feed upon dead fish that they find floating on the surface.

Gulls and terns are much alike in their nesting habits, for the majority of species build crude nests or lay their eggs in simple depressions in the sand or on the rocks with little or no pretense at nest building. In this respect and also in their eggs, which are olive or drab in ground color, rather heavily marked and sharply pointed, they are quite similar to the sandpipers and plovers. Indeed, they resemble the shorebirds in other respects as well and in many anatomical characters so that most ornithologists today put all of them together in one major group or order.

The commonest and best known of the 25 species of gulls that are found in North America is the herring gull. It is found throughout the northern hemisphere, nesting from northern United States and northern France northward and wintering from the southern part of the breeding range south to the Gulf of Mexico and the Mediterranean. It is common in winter in New York harbor and in other harbors, following the ferries and swooping down to pick up pieces of bread or refuse thrown into the water. It also follows the garbage scows in dense clouds and is everywhere a valuable scavenger. In the interior the herring gulls are common on all of the Great Lakes and larger bodies of water that do not freeze over, and whenever the ground is not covered with snow they make sorties on to the uplands, often long distances from water, where they find grasshoppers, beetles and grubs. Gulls always roost on the water, however, so toward night they can be seen returning to the lake just as they left it in the morning. While on the lake, in addition to picking up dead fish, they occasionally rob the loons and mergansers. Sometimes a dozen or more gulls hover over the spot where these birds are fishing, waiting for one of them to make a catch, and then they swoop down at it before it has time to swallow the fish. Usually the gulls are so persistent that the diver finally drops the fish, whereupon the gulls fall upon it and begin fighting among themselves.



Photos A A Allen

HERRING GULLS AND CROWS AT A FEEDING STATION

RING-BILLED GULL (captive)

The herring gull usually selects a rocky island for a nesting site and pulls together a small pile of drift weed for a nest. It usually lays three eggs which vary from drab to olive or bluish-white in ground color, irregularly spotted with lilac and shades of brown. The young birds are covered with down when hatched and like the adults are able to swim. They are cared for by their parents, however, until they learn to fly. Their downy coat is mottled with buff and gray so that when they crouch they are almost invisible against the lichen-covered rocks.

Ten of the fifty species of terns known to science are found in North America. They are easily distinguished from the gulls by the points already mentioned, but many of the species are distinguishable from one another only by the closest observation. The commonest color pattern is similar to that of the gulls, being largely white with pearl-gray mantles, but in the breeding season all the typical species have the whole top of the head black. Most of them, likewise, have deeply forked tails. They vary in size from the least tern, which is not much larger than a swallow, to the royal and caspian terns, which are about the size of ring-billed gulls. The caspian tern is a somewhat larger species than the royal and has a less deeply forked tail. It is likewise more northern in its distribution. The common or Wilson's tern, the Forster's tern, the arctic tern and the roseate tern are all much alike, being about 15 inches long and having the typical tern coloration. They are, however, somewhat different in habits and distribution, the common tern being the most widespread and generally seen. Close observation will distinguish the arctic tern by its grayer underparts and uniformly deep red bill, the common tern by its white throat and grayish breast and bill, red only at the base. The Forster's tern can be distinguished by its pure white underparts and dull orange bill, and the roseate tern by its delicate tint of pinkish on the underparts, but all four are about the same size and distinguishable only at close range.

The arctic tern is the most maritime of them all and is said to have the longest migration of any bird, some individuals nesting well within the Arctic and some wintering well within the Antarctic Circle, requiring an annual pilgrimage of about 22,000 miles.

In the days when the millinery trade in feathers was at its height thousands of tern skins of all species were shipped to the New York markets and the breeding colonies all along the Atlantic Coast were almost exterminated. Indeed, even after some of the nesting islands were set aside as refuge and protected by wardens, hunters congregated on the sea near the islands and baited the birds up to them. In this way they were still able to kill hundreds of them because the terns have the unfortunate habit of hovering over a wounded companion and returning again and again, even though shot at, as though they would succor him. It was not until through the efforts of the National Association of Audubon Societies and a few far-sighted representatives and senators that laws were passed forbidding the sale of the plumage of native birds, that it was possible to save the few remaining terns. Now the birds are beginning to increase and to nest where they have not been found for years. The least tern alone seems unable to recuperate from the verge of extermination to which it was forced and it is still a rare bird all along the Atlantic Coast where once it was abundant, though recently it has shown an increase on the New England coast.

Photo H. K. Job

ARCTIC TERN ON ITS NEST

Photo A. A Allen

BLACK TERN AT ITS NEST

The graceful herons

When nature evolved the heron to enliven the shores, she did not take into account the avarice of man nor the vanity of woman She created a bird that

THE LITTLE EGRET

should have stood for all time as the emblem of grace. Take away the heron's life and the genius of the artist is gone — there remains an ungainly mass of spindly legs and crooked neck worthless even for

Photo A A. Allen

NESTS OF THE GREAT BLUE HERON
In a dead elm in a swamp.

food. Nature might have expected, therefore, that the heron would be allowed to live and delight the eyes of mankind forever. Unfortunately, however, she decorated certain of them during the breeding season with most beautiful and delicate plumes which retained their beauty even when ripped from the backs of their owners. This signed their death warrant. Shrewd milliners, playing on the vanity of women and the relentlessness of fashion, saw in these plumes a fortune. Fashion and ignorance did the rest, so that today the most beautiful species, the egrets, are nearly extinct. Indeed, they might long since have been so had it not been for the determination of a group of bird lovers who formed the National Association of Audubon Societies and for the far-sightedness of a nature-loving President of the United States, Theodore Roosevelt, who set aside certain areas of waste land as Federal Bird Reservations to give the vanishing birds a last resort of safety.

There are about 100 species of herons (family *Ardeidæ*) in the world, found mostly in tropical and subtropical regions, but at least a dozen are found in the United States and Canada. They vary in size from the least bittern, whose body is not much larger than that of a robin, to the great blue heron that stands about four feet in height. In color they vary from the streaked brown plumage of the bitterns, through various shades of blue gray and chestnut, to the snowy white of the egrets. They are variously ornamented with elongated feathers, either on the crown, foreneck or, as in the egrets, on the middle of the back. In the bittern there are some fluffy white feathers beneath the wings that are displayed during the courtship performances.

The majority of herons are gregarious birds, roosting and nesting in colonies. They scatter when fishing, however, and hunt singly, either stalking quietly through the shallow water or resting motionless along the shore waiting for some luckless fish to swim within reach of their javelin-like bills. One species, however, the reddish egret, is said to run rapidly through the shallow water in pursuit of small fish.

Most herons nest in the trees or large bushes of extensive swamps but the bitterns nest on the ground in treeless marshes. Herons' nests are always poorly made structures of sticks so thin that the pale bluish or greenish-white eggs can usually be plainly seen from below.

Young herons are covered with long shaggy down when hatched, and even before they acquire their real feathers they are able to climb from the nest and cling to the branches, using their wings and even their necks to assist them. If they drop into the water below, they are able to swim, though not very duck-like since their heavy bodies sink until only the head shows above the surface. They use their wings as well as their feet for propulsion. When alarmed in the nest or on the branches, the young herons stretch up their long slender necks and remain perfectly quiet so that they look more like sticks than like birds. They are fed in an odd manner. The old bird, having swallowed the fish or frogs which it has caught, returns to the nest with them in its crop. The young bird then seizes with a scissor-like action the base of the bill of the old bird which turns its head on one side and vigorously but deftly disgorges the food into the throat of the young.

Photo A. A. Allen

GREEN HERON NEAR ITS NEST

The alluring waterfowl

To one who is fond of nature in her wilder moods, there is nothing more fascinating than the flight of the waterfowl (family *Anatidæ*). Seen against a leaden sky or against the first flush of dawn, the eye follows the sweep of their rapidly moving forms until as merest specks they disappear into the haze and one is left with a feeling that nature is not yet vanquished, that there are still great spaces unexplored, that man, after all, is but one small part of the great creation. Vast stretches of brown marsh, waves lapping on the lake shore, or surf pounding on the headlands furnish the frame for a picture that clings to one's memory. There are crystals of snow in the air that cut the face as they are driven before the blast; frozen spray covers the blind and the hunters that lie in wait behind it and the floating decoys; Æolus plays a tune in the gun barrels. The uninitiated wonder how men can endure such privations and call it sport, but they have not seen the picture, nor heard the music of the wind and the waves and the whistling wings that find their response in the hearts of those who go down after ducks.

Photo A. A. Allen

AMERICAN BITTERN

Crouching over its young, preparing to defend them

Therefore let us wisely conserve what we have, and, as the number of hunters increases, let the open season be shortened and the bag limit lowered. Let us propagate waterfowl in captivity to restock the marshes so that our children's children may still view the picture that made its appeal to our forefathers and to us.

There are over 200 species of waterfowl in the world, of which about 50 are found in North America. They are grouped into five sub-families or groups that are rather easily distinguished: the swans, the geese, the mergansers, the dabbling

Photo A A Allen

LEAST BITTERN ON ITS NEST

Assuming an attitude like a broken reed to escape detection

ducks and the diving ducks. The swans have much longer necks than the other waterfowl, even longer than their bodies. The geese have shorter necks than the swans but longer than the ducks. The mergansers differ from all the others in their narrow, serrated bills. The dabbling and diving ducks are readily distinguished from the swans, geese and mergansers but are not so easily separated from one another unless one can observe their method of feeding or distinguish the lobe on the hind toe which characterizes the diving ducks. The dabbling ducks frequent the marshes and lake shores where they can feed in shallow water by tipping. They feed mostly at night or on dark days and spend the bright days at a safe distance from land. They usually occur in small flocks of from five to twenty, those of over a hundred being rare. They migrate earlier than the diving ducks and most of them have left the Northern States by the time the snow flies and the ponds and marshes have frozen They winter from North Carolina to the Gulf and some species go as far as northern South America. The dabbling ducks are likewise called river ducks and summer ducks.

The diving ducks, sea ducks or winter ducks, on the other hand, often occur in flocks of several thousand and feed in deep water, often far from land, for they dive readily and secure their food of molluscs or the roots and buds of aquatic plants in water up to 100 or 150 feet deep They are not influenced by the freezing of the marshes and shallow water, therefore, and migrate later in the fall, and winter further north than the others. They are less exposed than the dabbling ducks to enemies while feeding and therefore feed more during the day than at night. They are better adapted for diving than the dabblers, having larger feet, stockier bodies with shorter necks and shorter wings, characteristics which enable one, when familiar with them, to distinguish the two groups of ducks on the wing at a considerable distance. On the water, the diving ducks rest lower and do not hold their tails up from the water as do the dabblers.

The swans

Of the eight species of swans, there are two found in North America. Both species are pure white except for the black bill and feet and a yellow spot between the eye and bill that distinguish these whistling swans from the trumpeter. They both resemble very closely the domesticated swan of ornamental ponds which has been derived from the European mute swan and which can always be identified by the hump or knob on its bill. The trumpeter swan is today one of the rarest of North American birds. The whistling swan still holds its own in a few places,

THE GRACEFUL SWANS AND THEIR CYGNETS

now that it is protected by law, and every winter large flocks congregate on Currituck Sound and a few other good feeding areas. In summer the whistling swan retires to the Barren Grounds to breed, where it is said to be very conspicuous on its nest but able to defend itself against all enemies up to the size of a fox.

Swans are noisy birds and when feeding or disporting themselves their loud clarion-like notes can sometimes be heard for several miles. They can swim very rapidly and outdistance a man rowing a boat, so that they do not take wing unless hard pressed. On the wing swans are easily distinguished by their large size, long necks and pure white plumage, not even the flight feathers being dark.

The geese

Of the twenty-five species of geese in the world eight are found in North America; of these the Canada goose is the most abundant and best known. They nest from northern United States northward to the limit of trees and winter from the Great Lakes southward to the Gulf. Their comings and goings are the most conspicuous bird migrations that we have. One hears their loud honking long before he sees them as they travel high overhead in a great wedge or Y, led probably by an old gander They migrate both by day and by night and sometimes on foggy nights apparently get lost and are attracted by the city lights and swing low

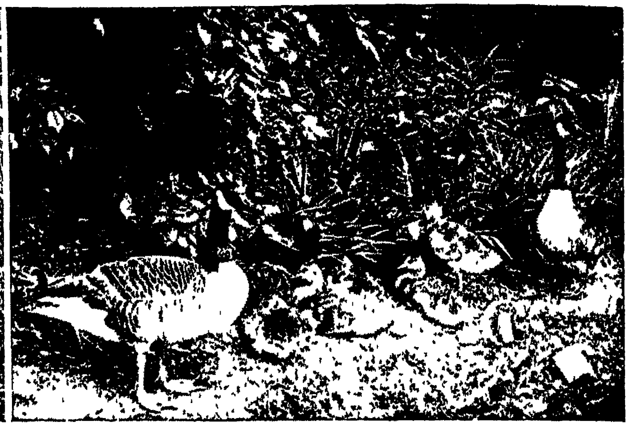
Photos A A Allen

A LESSER SNOW GOOSE

The bird (captive) is shown in winter.

BRANT GOOSE (captive)

A common goose along the Atlantic coast



Photos A A Allen

CANADA GEESE (in captivity)

A pair at their nest, the gander standing guard — A pair with their young, the gander at the left, the goose at the right

over the housetops honking loud enough to waken even the soundest sleeper On their migrations they are great vegetarians and are fond of grazing on the young wheat, both in the spring and in the fall. In the South on their wintering grounds, however, they seem to prefer to feed in the shallow water of the bays and lagoons, tipping for aquatic plants and organisms like the dabbling ducks.

Geese are said to mate for life and certainly in captivity it is difficult to get old birds that have lost their mates to make another choice The male goose is a dutiful husband and assists his spouse in guarding the eggs and caring for the young. He is able to deliver a severe blow with his wings, which are armed with bony knobs at the first joint, and he is, therefore, far from helpless even when he has shed all of his wing feathers and is unable to fly

The Canada goose differs from the other species in having broad triangular patches of white on the cheeks which meet on the throat. The Hutchins, white-cheeked and cackling geese are western representatives of the Canada goose. The two species of brant are similar to the Canada geese in having the head and neck black and the body grayish brown, but the white is confined to a few white streaks forming a collar on the neck. They are considerably smaller and are confined mostly to the seacoast, the black brant to the Pacific Coast and the common brant to the Atlantic. The snow geese are easily recognized because they are pure white except for their black flight feathers The eastern greater snow goose is larger than the western lesser snow goose A still smaller and rarer species, the Ross snow goose, is likewise found in parts of the West In Alaska there is another species, the Emperor goose, which rarely comes south into the United States. It has a white head and tail and a bluish gray body more or less specked with white The chin and throat are dark, a constant difference from the rare blue goose, which is a similar looking bird, of eastern North America The breeding range of the blue goose in northern Canada is unknown but it winters in considerable numbers in Louisiana The white-fronted goose is very similar to the European grayleg goose and therefore to our domestic geese, which have been derived from it, with the exception that the region around the base of the bill is white in the native species.

The fish-eating mergansers

The mergansers, sheldrakes, saw-bills or fish ducks, as they are variously known, form a very distinct group of waterfowl, easily distinguished by their narrow serrate bills and their crested heads. Three of the nine species are found in North America but they are not valued as food because of their fish diet. Individuals of the two smaller species, the hooded and red-breasted mergansers, however, are

Photo Francis Harper

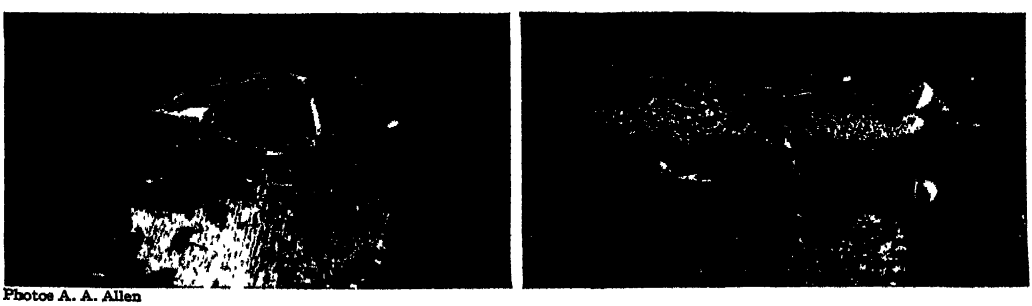
RED-BREASTED MERGANSERS PASSING OVER DECOYS

often eaten and are pronounced as good as many of the true ducks. The females of all three species are grayish birds with conspicuously crested, reddish-brown heads, the crest of the small hooded merganser being the largest. The males are conspicuously marked black and white birds, the male hooded being one of the most ornate of the waterfowl.

Mergansers secure their food by diving and pursuing it beneath the water, using only their feet for propulsion. They first locate their prey by lowering their heads until their eyes are beneath the surface film and they can often be seen swimming along in this attitude. Their serrate bills with the hook-like nail at the tip seems well adapted to holding their slippery prey. Mergansers nest either in holes in trees or in crevices in the rocks and, like other ducks, lay whitish unspotted eggs.

The dabbling ducks

All the domestic ducks, and most of the ducks that are commonly known, belong to this group. Indeed, all the breeds of domestic ducks from the white Pekin to the Indian runners, with the exception of the muscovy are thought to be descended from one species, the mallard or common wild duck, which is a typical member of this group. The muscovy is a very distinct species native to the West Indies and northern South America. The wild



Photos A. A. Allen

MALE GREEN-WINGED TEAL AND A PAIR OF BLUE-WINGED TEALS (captive)

The green-winged teal is the smallest of our ducks

mallard differs but little in coloration from the domestic breed, the males having bright green heads and white rings around their necks and the females being uniformly streaked yellowish or grayish brown. Under domestication mallards change considerably, becoming much heavier, and having fatter heads. In the wild state the mallard is found all over the northern hemisphere, though in North America it is more abundant in the West and in the Mississippi Valley than in the East. Here its place is filled by the black duck or black mallard, as it is sometimes called, a warier species that is better able to take care of itself in more closely settled districts. Male and female black ducks are alike except for their bills, which in the males are yellow and in the females olive. They are uniformly brownish black except for snowy white lining of the wings which likewise contain purple patches. Both the black and mallard ducks feed to a considerable extent in the grain fields in the northern states, spending the day out at sea or on the larger bodies of water and feeding only at night. They are likewise residents of the marshes where they are most successfully hunted.

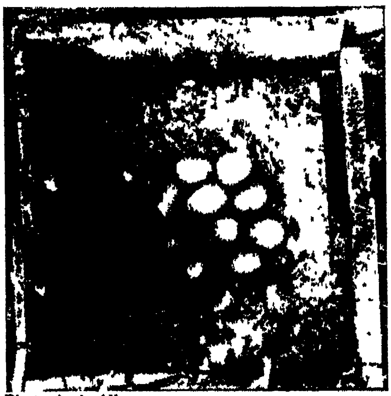


Photo A A Allen

NEST AND EGGS OF THE WOOD DUCK (in captivity)

The down has been plucked by the female from her own breast

Space permits only a mention of the other dabbling ducks, of which there are ten other species found in North America. The best known of these are the pintail, the baldpate, the shoveler, the gadwall, the blue-winged and green-winged teals and the wood duck, the last being the most brilliantly colored of all. Its crested purplish green head, variously marked with white, its purplish chestnut breast and its buffy flanks all tend to make it a striking bird much desired on ornamental ponds. The males of the other species are quite beautifully marked in their breeding plumage with whites, browns, blues and metallic colors but the females are uniformly plain. The fall plumage of the male birds, which is donned in late summer and worn for but a short time while the flight feathers are being replaced, resembles that of the females which is the same throughout the year. This early fall plumage of the males, which is never worn all winter as with most birds, is called the "eclipse" plumage. It serves to make the birds less conspicuous during the period when they are replacing their flight feathers and are comparatively helpless, for unlike most birds these feathers are all shed simultaneously and the bird is without the power of flight for several weeks until the new ones are grown.

With the exception of the wood duck, all of the dabbling ducks regularly nest on the ground, usually near water, but sometimes a half a mile from it and in quite exposed situations. The nests are crude affairs of grasses and weeds, but as incubation proceeds the female plucks down from her breast with which she covers the eggs to make them inconspicuous and to keep them warm when she leaves them to feed. For the males never assist in household cares, but as soon as the eggs are laid they congregate in flocks by themselves and show no further interest. The wood duck is a notable exception for in the first place it nests in a hole in a tree and in the second place the male attends the female and assists in incubation and such care as the young receive

The wood duck has always been much in demand because of its bright colors, and as it is not a very wary bird, it has fallen an easy prey to gunners until it has become very rare over a large part of its extensive range. Fortunately it is now quite easily reared in captivity and is therefore in no danger of absolute extinction.

SOME DABBLING DUCKS

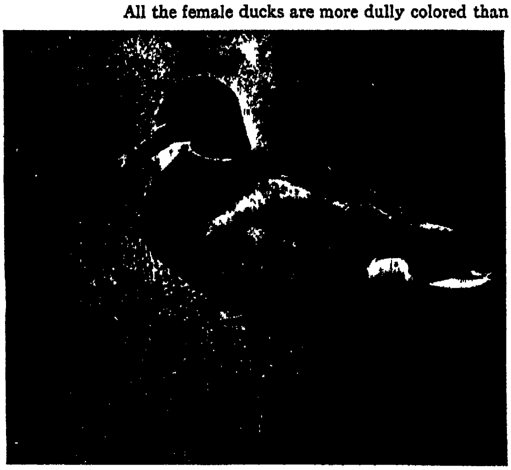
MALE WOOD DUCK IN ECLIPSE PLUMAGE
Worn during July and August.

MALE WOOD DUCK IN BREEDING PLUMAGE
The most beautifully colored of all our waterfowl.

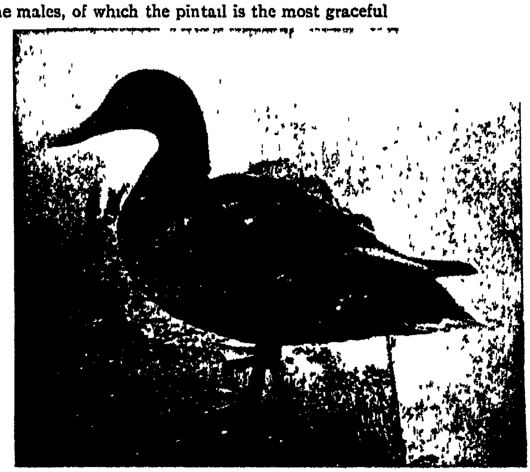
FEMALE PINTAIL DUCK

MALE PINTAIL DUCK

All the female ducks are more dully colored than the males, of which the pintail is the most graceful



MALLARD DRAKE (captive bird)
In breeding plumage.



THE SAME DRAKE IN A DIFFERENT SUIT
In eclipse plumage

The black and white illustrations on this page and the succeeding pages of this chapter are from photographs by A. A. Allen.

The diving ducks

There are seventeen species of diving ducks found in North America, some of which are very abundant, flocks of several thousand scaup ducks, for example, being a not uncommon sight on our larger bodies of water. The diving ability of these ducks can scarcely be exaggerated, for some members of the sub-family, notably the old squaws, are repeatedly captured in gill nets set for fish in from 100 to 150 feet of water. Indeed, almost every year in the Great Lakes, thousands of these ducks are said to become entangled in the nets and drowned The old squaws, scoters and eiders are believed to use their wings as well as their feet in diving, but the rest use only their feet which are much larger than in the dabbling ducks. Their feet are likewise set farther back so that when on land they stand more erect or rest on their breasts and walk with difficulty. In nesting they prefer the marshes so that they can slip from their nests into the water without having to walk on dry land. With one exception they are northern breeding ducks, nesting from the northern tier of states northward.

The choicest of all the diving ducks is the canvasback, so called from the white back of the male The back of the female is gray and the head and neck cinnamon brown instead of rufous as in the male A somewhat similar species is the redhead whose head is brighter red and whose back is grayer, not to mention other differences. The long bill and sloping profile of the canvasback is a good distinguishing mark in any plumage. The reputation of the canvasback has been gained largely through its habit of feeding upon the wild celery (*Valiseneria*) which is believed to impart the pleasant flavor. Other ducks feeding upon the same food are said to be quite as well flavored.

CANVASBACKS ON CAYUGA LAKE IN WINTER

Other ducks of this group are the greater and lesser scaup ducks, bluebills, broadbills or blackheads as they are variously called, the ring-necked duck, the curious little ruddy duck with its upturned tail, the two species of golden-eye and the bufflehead which nest in trees, the scoters or sea coots of three species, and the four species of eider ducks from which comes the eider-down of commerce, though most of it is secured from the European birds. The down is secured by robbing the nests of the down which the female bird pulls from her own breast to cover the eggs

SOME COMMON AMERICAN WATER BIRDS

In Iceland and other northern countries where the birds occur, the wild birds are induced to nest in places made for them, and they live in an almost semi-domesticated state because they are given complete protection.

The Labrador duck, which once occurred in winter along the Atlantic Coast as far south as New Jersey in considerable numbers and which is now extinct, also belonged to this group of diving ducks. The last specimen of this duck was taken in 1871 and the cause for its extinction is not known It is suggestive, however, of what may occur to many others of our ducks if constant watchfulness is not maintained to adjust the protective laws to any decrease that may occur. The wild fowl are a great asset to the country and we cannot afford to lose them. So we must keep up a constant vigilance to see that our laws give them all the protection they need and that these laws are respected and enforced.

A RED HEAD DUCK (captive bird)
Note the large feet, set far back.

Marsh-loving rails, gallinules and coots

"Thin as a rail" is an expression that applies as well to any of the members of this family of curious birds as it did to the parts of Abraham Lincoln's famous fence. For they are marsh dwellers, and nature has seen to it that their bodies are much compressed, shaped like that of a flea, to enable them to slip better through the dense vegetation.

There are about 180 species in the family (*Rallidæ*) but only 15 are found in North America and of these but 4 or 5 are common even in the most suitable localities. By most people they go unseen and unknown, for unless one haunts the marshes he is apt never to see one. When a coot or a rail meets with an accident on its migration and is picked up by the corner grocer or the editor of the local newspaper, it always causes considerable excitement in the community, for it is usually diagnosed as a hybrid between a duck and a chicken or, if one of the smaller species, a cross between a snipe and a quail.

All the members of the family have rather long, stout legs like fowls, but their toes are always long and slender to distribute their weight better when running over the soft ooze or the floating vegetation. The coot has lobes on each side of its toes to assist it in swimming, for it is much more aquatic than the other species and often assembles on the open water in large flocks like ducks. All species have longer necks than ordinary birds and much shorter tails which, like domestic fowls, they hold erect when walking. Their wings are short and rounded, which adds to their chicken-like appearance, but their feathers are longer and softer than chickens', giving their plumage a somewhat hairy appearance The gallinules and coots, the sora, yellow and black rails, have short, thick, pointed bills, but the Virginia clapper and king rails have rather long, slender and somewhat decurved bills.

The coot and the Florida gallinule, which are perhaps the best-known members of the family, are sometimes called mud hens or "water chickens". They are similar in general appearance, being uniformly slate color and about the size of bantams.

A COOT (in captivity) SHOWING ITS LOBED TOES

FLORIDA GALLINULE ON ITS NEST

If one cannot see the lobes on the toes of the coot, another good field mark is the ivory-white bill which in the gallinule is red and green. Both species have what is called a frontal shield, a horny prolongation of the bill on the forehead, which is not found on any of the rails. In the gallinule it is bright red and quite conspicuous but in the coot it is smaller, brownish and inconspicuous. When swimming both species are quite duck-like but their heads are smaller and they are continually jerking them after the manner of pigeons. When flushed they patter along the surface for a considerable distance before they rise, but when fully on the wing they resemble small ducks. When on land or stepping along the border of a marsh, on the other hand, they do not resemble ducks in the least but appear more like busy little hens, picking at everything as they step along, but lifting their feet rather high and putting them down carefully as though they were always sneaking up on some wary insect or crustacean. They are never as cautious, however, with their voices, and some of the most startling sounds that ever come from the marshes can be traced to them. Their ordinary calls are somewhat hen-like *cut-cut*, or *cak-cak*, but occasionally they give vent to a thunderous, WUP, PUP, PUP, PUP, PUP or WUP — WUP — WUP. Like the rails they are especially noisy early in the morning and toward dusk and occasionally break out in the middle of the night.

SORA RAIL APPROACHING ITS NEST

They build their nests of dried rushes close to the water level in the marsh vegetation, the coot usually in deeper water than the gallinule and in more open situations. Often they have to add to their nests during periods of high water to keep the eggs dry. The eggs are buff in ground color, rather evenly marked, the spots on the coot's eggs being smaller and blacker than those of the gallinule.

The young birds are covered with black down when hatched, the coots being curiously ornamented with a fringe of orange whiskers. They are able to run and swim shortly after hatching and follow their parents about, hunting for food. It is an interesting sight to see a family of gallinules threading their way along the border of a marsh, the old ones continually calling and the young constantly peeping so that they will not get lost. As though to give the young something to follow, the old birds continually flash their white under tail coverts as they jerk along. At times the young get tired and crawl up on the back of the mother or again she calls them all to her and broods them for a while on little platforms of rushes or temporary nests which she constructs.

The commonest and best known of the rails is the Virginia rail, a bird about the size of a robin but of very different shape with its small head, long bill and long legs. In general color it is dark brown, somewhat streaked on the back, redder on the breast, the flanks being barred with black and white.

It is found even in the smallest marshes, from the Atlantic to the Pacific, nesting from the Middle States to Ontario and British Columbia and wintering from the southern parts of its breeding range to Central America. It is often heard but seldom seen, for it is rather difficult to flush even when one follows its notes out into the marsh. It seems to prefer to dodge through the thick vegetation like a mouse, sometimes when cornered doubling back almost between one's feet instead of flying.

Rails, gallinules and coots are all considered game birds and are shot in considerable numbers, especially in the South. The rails are very small, however, their flesh is of inferior quality, and they are such weak fliers that they furnish a very low grade of sport for hunters.

The sandpipers

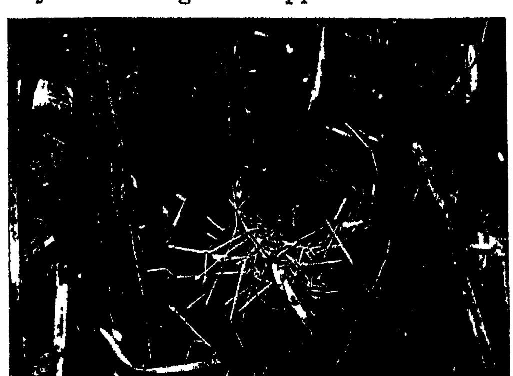
When the waters in our lakes and ponds recede during late summer and leave exposed great areas of soft mud, they would become very unattractive were it not for the flocks of graceful little birds that assemble upon them. With jerking heads or tilting tails they trot along the soft oozy shore in search of the larvæ that lie concealed in the mud. These are the sandpipers (family *Scolopacidæ*). There are tiny ones, smaller than sparrows, and there are larger ones as big as pigeons; sometimes in separate flocks; sometimes all mingled together. They are brownish or gray above and white below, with slender legs and long slender bills, and except for their size all look much alike.

YOUNG GALLINULE A FEW HOURS AFTER HATCHING

It takes a sharp eye to distinguish the different species when they have assumed their fall plumages. But it is in this plumage that we see the most of them, for on their way north in the spring the waters are high, mud flats are scarce, and they are in a hurry to get to their nesting grounds. In their breeding plumage many of the species are strikingly marked with black or chestnut and are easily distinguished from one another, but in the fall it is different. They constitute a post-graduate course in bird study that appeals to those who have passed through the warblers and the sparrows and the flycatchers and are ready for more difficult problems.

Together with the plovers, the avocets and the stilts, the turnstones and the phalaropes, the sandpipers make up the great group of shore birds. The plovers have much shorter bills than the sandpipers, the avocets and the stilts much longer legs, the turnstones squarish bills, and the phalaropes, lobed toes, but they are all very similar in general appearance.

VIRGINIA RAIL APPROACHING ITS MARSH NEST



VIRGINIA RAIL INCUBATING

SPOTTED SANDPIPER STEPPING ON TO ITS NEST

There are about 100 species of sandpipers, most of them being confined, except on their migrations, to the northern parts of the northern hemisphere, many of them nesting within the Arctic Circle One-fourth are found in North America, some of them confined to the West, some to the East, but the majority nesting in the Far North and following in their migrations the routes of abundant food Thus they are more common along the sea-coast.

They are great travelers, perhaps the greatest of all, some of them traversing the entire length of both continents in their migrations. The majority of species spend the summer in the Far North and, in the fall, though some of them stop on our Gulf Coast, the majority speed on their way across the Caribbean to northern South America and some continue down the coast even to Chile and Patagonia. When they leave their summer homes they have stored up great layers of fat, but when they reach their winter quarters, the majority have grown thin. Particularly is this true of those that follow the route of the golden plover on the long flight from Nova Scotia to Venezuela or from Alaska to the Hawaiian Islands without a single stop. Twenty-five hundred miles in a single flight seems almost incredible, but such is the accepted belief today with regard to the plover and other shore birds that accompany them. Indeed they have been seen passing over the Lesser Antilles as though untired and continuing on to the mainland of South America though good stopping places were plentiful. When instinct compels birds to make such a trip, it is little wonder that it carries some of them on southward far beyond the bounds of reason and good sense, even to Cape Horn, perhaps 9000 miles from their nesting grounds

In former years all of these shore birds were considered game birds and were shot in such numbers that some of the species were nearly exterminated. This was possible because they ordinarily fly in close flocks so that many can be killed at a single discharge of the gun. Now, through the Migratory Bird Treaty with Great Britain, they have passed under federal jurisdiction and all save a few species are given protection. Of all the shore birds, only the yellowlegs, Wilson's snipe, woodcock and the black-bellied and golden plover remain on the game list for which there is an open season.

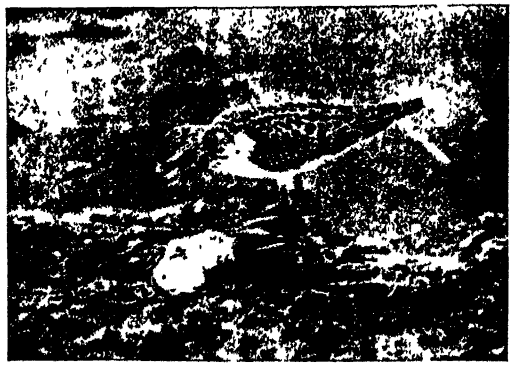
The commonest species of sandpiper is the spotted sandpiper, "tip-up" or "teeter-tail", as it is variously called. In summer it is found along almost every stream and lake from northwestern Alaska to Louisiana, and in winter, from Louisiana to southern Brazil. It can be distinguished from the other sandpipers of its size, about that of a sparrow, by the conspicuous spots on its underparts. In the fall, however, these are lost, when it would be hard to identify were it not for its constant teetering Several other species, and especially the solitary sandpiper, jerk their heads when they walk but the spotted teeters its tail or its whole body as though it has difficulty in balancing on its slender legs. It flies with a peculiar hovering movement of its wings which show a narrow gray line down the middle. The Wilson's snipe is quite different from other sandpipers and prefers the grassy marshes and seldom ventures out on the bare flats except early in the morning and at dusk. The Wilson's snipe is a better game bird than the other small sandpipers because of its habits. It sometimes travels in flocks but they scatter when feeding and do not get up together nor afford a "pot" shot. They ordinarily escape detection until they jump with a somewhat startling "kick" or "bleat" and quickly get off on a zigzag course that puzzles the hunter.

Even more aberrant among the sandpipers and the best game bird of them all, is the woodcock It never ventures out into the open except after dark, but spends the day usually in alder thickets, though sometimes at a considerable distance from water. Because of the nature of its haunts, it makes a difficult target for the hunter. It has, however, the unfortunate habit of never flying very far and allowing itself to be flushed and shot at time and again. Once in its winter quarters in the South, it remains in the same thickets until time to move northward again, so that hunters with dogs have nearly exterminated all the birds wintering in some localities.

The woodcock is one of the most protectively colored birds that we have and, on the nest, it frequently relies entirely upon its coloration and will allow itself to be touched while incubating.

With the exception of one species, all of our sandpipers nest on the ground. The exception is the solitary sandpiper which, so far as is known, utilizes the old nests of other birds like the robin and grackle, sometimes at a considerable distance above ground and away from the water. All sandpipers lay three or four very large eggs for the size of the bird, which are sharply tapered so that they will fit together like the pieces of a pie. Otherwise the old bird would be unable to cover them They are usually buff or tan in ground color, with some species greenish, heavily spotted with black or brown.

Young sandpipers are covered with down when hatched, many of a striped pattern, and are able to run about and follow their parents or even swim across streams. The first plumage is similar to that of the adults in the fall, and in the spring all molt into the breeding plumage. If there is a bright plumage, females don it as well as the males. Indeed, among the phalaropes, which are closely allied to the sandpipers, the females are brighter than the males It is interesting to note that with them the males are left to incubate the eggs and care for the young, while the females assume no responsibilities except laying the eggs.

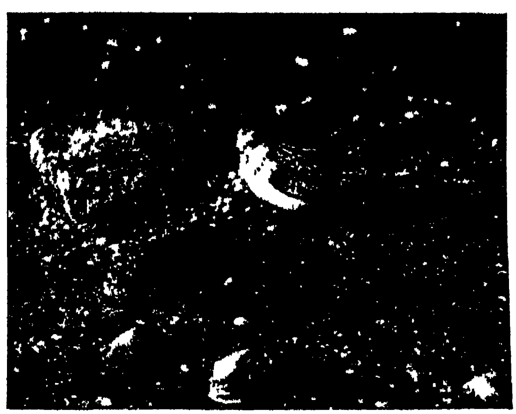


SEMI-PALMATED SANDPIPER FEEDING

The food of the sandpipers includes many mosquito and fly larvæ, and among some species grasshoppers and other destructive insects On the whole, however, the sandpipers commend themselves to us more because of their graceful appearance and charming ways. Our shores and mud flats would be desolate indeed with no birds to enliven them, and most people are glad to see all the smaller species removed from the game list.

The plovers

If travel is an education, the plovers must be an educated family (*Charadriidæ*). With their near relatives the sandpipers, they hold, with one exception, all records for long-distance flights. The one exception is the arctic tern, which nests within the arctic circle and winters within the antarctic, traveling some ten thousand miles over the sea twice a year. When it comes to actually seeing the world, however, there is no bird to compare with the



THE SANDERLING ON THE BEACH

golden plover. This bird nests on the arctic shores of North America and then flies southeast to Labrador, New Brunswick and Nova Scotia The 2500 miles of sea between Nova Scotia and South America hold no fears for it, and a direct flight is made over the Bermudas and Antilles, often without a stop The journey is then continued through Venezuela and Brazil to the pampas of Argentina. But not content with seeing this much of the world, this inveterate tourist seeks a different route for the return journey. Starting northwest from Argentina, it crosses Central America and enters the United States by way of the Gulf, traveling up the Mississippi Valley to Manitoba and Saskatchewan and thence to its breeding ground along the arctic shores. The two routes are fully 1500 miles apart.

KILLDEER PLOVER STANDING OVER ITS EGGS

The western golden plovers often start from Alaska for a direct flight to the Hawaiian Islands and thence to the islands of the South Sea. The golden plovers that nest along the arctic shores of Europe and Asia and winter from India to South Africa, are only slightly different from the American birds, and should we include them we may certainly claim the whole world in the range of this remarkable bird. It is somewhat smaller than a pigeon, with long pointed wings. Its upper parts are spotted with golden yellow and black, and its underparts are uniformly black in summer and grayish white in winter. A white stripe from the forehead down the side of the neck and breast is conspicuous in the summer plumage when set off against the black underparts.

Very similar to the golden plover is the black-bellied plover, which has a similar change of plumage with the seasons but always lacks the golden yellow spots of the upper parts. It is equally cosmopolitan, and in eastern North America, at least, is a more common species. Some of them pass the winter as far north as North Carolina, but others continue their flights to Brazil and Peru. Both species are similar in habits, frequenting shores and mud flats or even plowed fields or pastures. They fly in close flocks and appear like small ducks at a distance. Upon alighting they scatter to feed, running along the beach in search of stranded aquatic insects and crustaceans, which they pick up with a vigorous tilt of the body as though they were about to dive.

Both the golden and black-bellied plovers are still numbered among the game birds and are hunted either by means of decoys or by stalking them along the shore. They have rich mellow whistles which are quite easily imitated and they may often be drawn down to the decoys from a great height by the hunters.

There are about 75 species of plovers in the world, of which only 8, including the two mentioned, are found in North America. Of these, the most common is the killdeer, so called from its notes: "kill-dee, kill-dee, kill-dee", which constantly fill the air wherever these birds occur. They seem to have petulant dispositions, and find expression for their feelings through constant noise, so that the slightest disturbance or alarm starts them off. The majority of shore birds are confiding creatures, and unless constantly shot at will allow even the hunters to approach quite closely. Not so with the killdeer; it seems to have a special abhorrence of man and always espies one approaching at a great distance and starts "kill-deeing" so as to alarm the whole flock, and long before the other shore birds take wing it pitches off on a swift, erratic flight to some distant part of the shore. Its wings are long and pointed, and the speed which it develops when once under way is as remarkable as the irregular course which it often pursues.

INSTINCT AND EMOTION

The Deep-Seated and Universal Influence of Instinct, and Its Inseparability from Emotion

THE MODERN STUDY OF PSYCHOLOGY

WE are now about to plunge into what St. Augustine called "the abyss of the human mind". We have studied the senses, the memory, the mechanism of speech, and we have to look now at what Wordsworth called "the very pulse of the machine". It feels, is impressed, combines and retains impressions, but, furthermore, it does things Why and how? All that we have yet dealt with is only preliminary, after all, though there are many textbooks which deal with nothing else, as if the intelligence were the whole of man. The intelligence is only a method, a mechanism, a mode of direction — for the purposes of that whose purposes they are, and whose intelligence it is. We must get down to the springs of action, to the very pulse of the machine.

In the study of reflex action, we saw how living creatures, including ourselves, may and do respond to stimuli. Light is felt, and the pupil of the eye contracts; a fist approaches, and the upper eyelid falls; we sit on a pin and rise rapidly, perhaps with a reflex expletive in addition. These are more or less simple reflexes, or reflex actions, and the study of them does not take us far enough when we want to understand the behavior of man. Nevertheless, we note that these responses, though in a sense automatic and mechanical, are yet not without meaning. They are for life. They express the intention and purpose and construction of the living thing *to live*. They are the mechanical expression of purpose, just like a machine, a gun, a locomotive or an electric piano, made by man and caused to "go" by means of the appropriate "liberating stimulus".

When we look at certain other kinds of behavior, evidently more complicated, such as throwing oneself into a fighting attitude or into another person's arms, or when we see a puppy or a child devoting itself to the examination of some novelty, we recognize a sort of resemblance to mere reflex action These higher types of action we call "instinctive"; and we know that a vast variety of human behavior, in small things and in great, belongs to this class. It is instinctive, natural, follows impulses which arise within us, of which we are conscious, but which, in a sense, we cannot be said to have invented We "find ourselves irresistibly drawn" to do this or that, as the moth flies to the light, or the infant's hand feels for its mother's bosom. If we believe in the doctrine of organic evolution, as we all do, we must try to trace and define a connection between those lowest forms of conduct by which, say, the amœba, "sensing" something edible, approaches it, and those by which a hungry man follows a sniff of an adjacent restaurant, or works night and day for money wherewith his children may be fed when he is dead.

The first, and in many ways the greatest, student of this subject was Herbert Spencer, whose "Principles of Psychology", has now passed its sixtieth birthday. Having recognized the theory of evolution to be a universal truth, Herbert Spencer sought to apply it to the evolution of mind. Thus he reached the conclusion that "instinct may be described as compound reflex action". In the simplest reflex a single impression educes a single response; in the working of instinct many

impressions combine to produce a manifold response, "and the higher the instinct, the more complex are both the directive and the executive coordinations".

Probably Herbert Spencer cannot guide us much further in this direction We are grateful for his help thus far. No doubt his definition is true and useful as far as it goes But, after all, it is only a physiological definition; it is only in terms of machinery, and it does not even allude to the psychical side of what is going on. Now, there *is* a psychical side. We may observe the amœba or the puppy, and define its actions as reflex, simple or compound But when we proceed to observe ourselves doing just similar things, in the presence of similar stimuli — food, novelty, danger, attraction — we cannot fail to notice that there is something more than machinery to reckon with.

The combination of how we effect with how we are affected

While we do what we do we also *feel.* We enjoy, or fear, or hate, or are curious, or what not If, perchance, we also happen to think, we shall doubtless credit the puppy, at least, with feelings not incomparable with our own; and thus we have established the fact that there is a psychical side to instinctive action. We not only effect, but are affected. Psychologists thus often and conveniently speak of the "affective" aspect of instinct.

But we heard nothing about this from Herbert Spencer, and yet it has only to be experienced at first-hand in and by ourselves for us to admit that it is at least as real and as important as anything in the world To hate, to fear, to welcome, to love, to be interested in — these are part of the very deepest and most *e*ffective, because the most deeply *a*ffective, substance of our being We must make a fresh study of instinct, plainly, for, in terms alike of action, of behavior and of feeling, this is at the very heart of things.

And psychologists have been studying instinct ever since Herbert Spencer laid the foundations of the new psychology, which is based upon life, and is in living contact with physiology from first to last.

Getting free from chaotic uses of the word 'instinct'

Two notable students on the subject in especial must be consulted, the late Professor William James and Dr. William McDougall, who has, by general consent, carried our knowledge of this subject further than ever before But first, lest we lose ourselves hopelessly, we must properly define our terms "Instinct" and "instinctive" are used so loosely in ordinary speech that they have almost ceased to have any meaning. As Dr McDougall says: "On the one hand, the adjective 'instinctive' is commonly applied to every human action that is performed without deliberate reflection. On the other hand, the actions of animals are popularly attributed to instinct; and in this connection instinct is vaguely conceived as a mysterious faculty, utterly different in nature from any human faculty, which Providence has given to the brutes because the higher faculty of reason has been denied them"

Thus we are told that people have an "instinct of subordination", that ancestor-worship is a "mere tradition and instinct", that if a drunkard is fed on fruit he will "become instinctively a teetotaller", that "the Russian people is rapidly acquiring a political instinct", that "the instinct of contradiction, like the instinct of acquiescence, is inborn". Such absurd instances show that the words in question are commonly used as cloaks for ignorance, and are substituted for any attempt to understand individual or collective actions which we are too lazy to analyze. Perhaps everyone uses the words in such ways in ordinary speech, but they must not so occur here.

Instincts — innate elements not acquired during the individual lifetime

In our discussion of "instincts" here we shall mean what the serious students of the mind always now mean by that term — "innate specific tendencies of the mind that are common to all members of any one species, racial characters that have been slowly evolved in the process of adaptation of species to their environment, and that

can be neither eradicated from the mental constitution of which they are innate elements nor acquired by individuals in the course of their lifetime" An instinct is thus something natural, genetic and is the very opposite of a habit Acquired habits of action, such as play a great part in our lives, may be called "secondary automatisms", and require careful study. The possibility of acquiring them may have an instinctive basis, but they are not instincts; and no writer of today who is really trying to find the facts of human nature ever says instinct when he means habit, or habit when he means instinct. Those who cannot perceive and steadily maintain in their minds the difference between what one does because one is so made, without any previous experience or understanding, or imitation or education or suggestion, and what one does because one has learned, say, to write, and with one hand rather than the other—those unfortunate people should not attempt to proceed further with psychology, where their predecessors have already caused muddle enough

The simplest life endowed with a power of adaptation

Let us go to a great student of the behavior of insects for further illustration of this all-important distinction. In the preface to Professor Auguste Forel's book on "The Senses of Insects", we find excellent definitions of true instinct, and of its ally and opposite, which is not instinct. Instinct in insects, as elsewhere, is inherited, like limbs or heart or muscles; "it is constant in effect, adapted to the circumstances of the special life of the species . . . this curious instinctive adaptation which seems so intelligent when it carries out its proper task, so stupid and incapable when diverted to some other purpose."

But, as Professor Forel insists, and his study of insects applies no less to ourselves, the living creature has also a power of personal adaptation, a "plastic or adaptive activity", which is other than instinct, but is its equal in importance. As he says, this personal power of dealing with circumstances is primitive. "It is even the fundamental condition of the evolution of life. The living being is distinguished by its power of adaptation. The amœba is plastic" By means of this power the living creature opens up new paths for adaptation to the unexpected, preparing by repetition secondary automatic activities which we call habits. Hence he reaches the following conclusion, which must be exactly quoted, for it dates as far back as 1900, and is notably similar to the teaching of Bergson in his "Creative Evolution":

A special automatic activity that reaches its summit in insects

"To sum up, every animal possesses two kinds of activity in varying degree, sometimes one, sometimes the other predominating In the lowest beings they are both rudimentary. In insects, special automatic activity reaches the summit of development and predominance; in man, on the contrary, with his great brain development, plastic activity is elevated to an extraordinary height, above all by language, and before all by written language, which substitutes graphic fixation for secondary automatism, and allows the accumulation outside the brain of the knowledge of past generations, thus leaving to the last the forces necessary to his plastic activity, at once the adapter and combiner."

This might be a passage from Bergson, except that the French philosopher would scarcely allow even so much of instinct in the make-up of man. As the reader will remember, Bergson sees in the insect the instinctive and in man the intelligent creature, and he has very little to say of instinct in ourselves. Here he follows the older view of the psychologists of the nineteenth century, who were inclined to suppose that instinct had all but lapsed in man, and that intelligence had taken its place They did not see that intelligence *does* nothing; it points, but it does not push. They regarded man as a creature with only very few instincts, and those weak and rather objectionable or derogatory to his dignity, for he is the reasonable creature, while the lower animals, they said, are not reasonable or intelligent, but behave in accordance with a great number of instincts with which they are endowed.

The contention that man has as many instincts as the lower animals

But, back in 1890, in his "Principles of Psychology", Professor William James set himself against the then generally accepted notions. All agree that man has had ancestors whose actions were mainly instinctive, but we can no longer assent to the view that, as man's intelligence and reasoning powers developed, his instincts atrophied, until now in civilized man instincts persist only as troublesome vestiges of his earlier state, vestiges that are comparable to the vermiform appendix, and which, like the latter, might with advantage be removed by the surgeon's knife, if that were at all possible James declared, on the contrary, and indeed proved, that man has at least as many instincts as any of the animals, and that they play a leading part in the determination of human conduct. And now Dr McDougall writes that "this recognition will, I feel sure, appear to those who come after us as the most important advance made by psychology in our time"

No doubt the notable feature of instinct in mankind is its great modification by the intelligence, and by habits acquired under the guidance of intelligence or by imitation. Further, in man this modification is made possible by the very development of his instinctive powers — a slow development which has long caused us to misunderstand their true character, and to put down as habit what was not "second nature", but *first* In mankind the instincts, though innate, are, with few exceptions, undeveloped in the first months of life, and only ripen or become capable of functioning at various periods throughout the years from infancy to puberty, or even later still

A single instance will suffice to show, once and for all, what we mean by a true instinct, in a highly developed form. "The mason-wasp lays its eggs in a mud nest, fills up the space with caterpillars, which it paralyzes by means of well-directed stings, and seals it up, so that the caterpillars remain as a supply of fresh animal food for the young which the parent will never see, and of whose needs it can have no knowledge or idea."

The instinct that is in ignorance of the purpose for which it exists

Here we see, in sharp outline, that notable fact of instinctive behavior upon which William James insisted — its ignorance of the purpose for which it exists There may be exceptions to this rule in the case of the lower animals, as there certainly are in man, but in them and in man it is true that, even though the purpose be perceived, it is not the perception of the purpose that impels to action. This is something deeper than foreknowledge, anticipation, conscious volition. How the mason-wasp, for example, can do what she does, having never done it before, having never seen it done nor having any slightest inkling of its clear, precise, exquisitely achieved purpose — that is a question which we cannot attempt to deal with now The point is that this independence of intelligence, of memory of the past or prevision of the future, is a characteristic mark of instinct, and our appreciation of it will aid us to realize the true nature of instinct.

An instinctive basis for all behavior without exception

If the case of the mason-wasp engaged in life's eternal business of maintaining itself against death seems too remote for our own case, let us take that of the youth who falls in love. Among the higher types of men love means much more than mere "reproductive instinct", and may cease to have any effective or necessary purpose of that kind. But that is its root. Herbert Spencer long ago pointed to this case to show instinct's independence of experience. The boy has never been in love before. He may have been brought up in such circumstances that he has never seen its manifestations, or, if he has, he has laughed at them, without the slightest understanding. But now life calls to him, and it is his turn. Habit, experience, initiation, understanding, appreciation of the vital purpose of all — these are utterly absent, but the boy falls in love, nevertheless, as he was made to do. Here is the case of an underlying instinct about which there could be no doubt, and of

which no one could pretend either that it was an acquired habit or that it was practically the same as one The argument now is that, if we look more closely, we shall see the instinctive basis for other forms of behavior — for many, for *all without exception*

We said that Herbert Spencer's definition of instinct was inadequate because it only described machinery. But instinct is palpably more than mechanical, even when we look at it from the outside. A mechanical process is arrested by any sufficient mechanical obstacle, but we all know that "Love laughs at locksmiths".

In more academic language — though no more accurately than our illustration — "the process, unlike any merely mechanical process, is not to be arrested by any sufficient mechanical obstacle, but is rather intensified by any such obstacle, and only comes to an end either when its appropriate end is achieved, or when some stronger, incompatible tendency is excited, or when the creature is exhausted by its persistent efforts"

And when we look again at an instinctive action from the inside, as we observe it in ourselves, we can recognize not only that it has its psychical side, but that this psychical side is threefold. We must understand it clearly if we are to be prepared for the great advance in psychology which we owe to Dr McDougall, and to which we are coming. Every instinctive act involves: (1) a knowing; (2) a feeling; and (3) a trying. We see or perceive some object, we have certain feelings about it and we strive in relation to it, towards it or away from it, or for it or against it. These feelings and strivings, however we shall afterwards define them, lie very deep in our nature, and affect our estimate and valuation of life beyond all else. It is in terms of them that we find life worth living or worthless, that we are happy or miserable. In more technical language, "the continued obstruction of instinctive striving is always accompanied by painful feeling, its successful progress towards its end by pleasurable feeling, and the achievement of its end by a pleasurable sense of satisfaction".

Never again, as in Herbert Spencer's definition, must we neglect the psychical side of instinctive processes, for it is all-important Here is the conclusion of Dr. McDougall's fine chapter, which since its publication has been read with gratitude and appreciation by psychologists throughout the world and to which every writer on these subjects must hereafter be permanently indebted.

The instincts the prime movers of all human activity

"We may say, then, that directly or indirectly the instincts are the prime movers of all human activity; by the conative [will-ful] or impulsive force of some instinct (or of some habit derived from an instinct), every train of thought, however cold and passionless it may seem, is borne along towards its end, and every bodily activity is initiated and sustained. The instinctive impulses determine the ends of all activities, and supply the driving power by which all mental activities are sustained; and all the complex intellectual apparatus of the most highly developed mind is but a means towards these ends, is but the instrument by which these impulses seek their satisfactions, while pleasure and pain do but serve to guide them in their choice of the means.

"Take away these instinctive dispositions with their powerful impulses, and the organism would become incapable of activity of any kind; it would lie inert and motionless like a wonderful clockwork whose mainspring had been removed, or a steam-engine whose fires had been drawn. These impulses are the mental forces that maintain and shape all the life of individuals and societies, and in them we are confronted with the central mystery of life and mind and will."

The myth that philosophers see things by the white light of pure reason

Observe, now, before we broach what seems to be another subject, how these conclusions bear upon the popular notion of the mind as a structure with watertight compartments. We talk and think as if the mind were really made of separate

things, such as, for instance, the intellect and the will, the realm of reason and the realm of desire Desire is thought to be a lower type of mental component, so that the ancient stoics taught that the wise and good man must extirpate all emotion from his bosom, while even Kant taught that "he should be free from desire".

It was further supposed that not until the wise and good man had accomplished this feat could he justly and securely reason. Other people saw things through a mist of feeling and prejudice, which gave everything the *couleur de rose*, or tinged it with jaundice. But the real philosopher must see things "as they are", by the white light of pure reason, the *lumen siccum*, or dry light which faithfully recorded facts, without caring one way or the other.

If we go back to the great writers, for great they undoubtedly were, of the nineteenth century, to Mill and Spencer and Tyndall and Huxley, we find ourselves being constantly exhorted to divest ourselves of any desire to find any particular truth, but to follow the pure light of reason, wherever it lead.

The universality of desire with strong personal instinctive motive

Meanwhile their critics could not go wrong, for they had no desires or prejudices or preferences (or motives, that would mean!), but used the *lumen siccum* alone. They did not realize that without desire no one acts, and that their own faithful research and passionate exposition was the best evidence in the world that they, too, like all the rest of us, were affected by the universal tendency to know what one wants in the way of beliefs and to see that one gets it.

Professor Tyndall's famous Belfast address illustrates our point. In it there occurs the fine passage: "But there is in the true man of science a wish stronger than the wish to have his beliefs upheld — namely, the wish to have them true." A noble sentiment, which we may all take to heart; but the speaker did not realize that the scientific passion for truth has itself an instinctive basis, and that we each of us have an instinctive structure which not only determines our search for truth, but our appraisement of it and our identification of it as true Tyndall himself says further on that "without moral force to whip it into action the achievements of the intellect would be poor indeed". Nay, more, we now see that without some kind of instinctive impulse within us, whether moral or immoral, the achievements of the intellect would be nothing at all The "pure intellect", the *lumen siccum*, the "philosophic detachment from desire" — all these are myths, which never were nor will be Let us aim at Tyndall's ideal, let us remember his warning, but let us fully realize, all the time, that desire, personal and particular in each of us, is the motive of all our doings, including the embrace of one we love, or the faithful calculation of angles in a trigonometrical problem. If we conquer desire and prejudice in the lower sense, that is only because we come under the sway of higher forms of desire and nobler prejudices

The combative instinct of eminent exponents of philosophic calm

It would perhaps be worth while, and it would be only too easy, to trace the influence of desire and of prejudice in many and many an observation of the thinkers whom we have quoted Anyone reading them now, without reference to the circumstances of the time, will marvel how Huxley could have said this, and Spencer that, and may incline to suppose that these men were sometimes very poor thinkers, after all. But reconstruct their emotional *milieu*, so that we see the entrenched forces, the bitterness, the narrowness, the insolence against which they had to fight, and we see at once that these men were themselves animated by inevitable prejudices and desires, no less certainly than the opponents whom they decried on that very same account. When a bishop could ask Huxley whether it was through his grandfather or grandmother that he claimed descent from a monkey, can anyone suppose that the *lumen siccum*, or the disengaged, volitionless, careless intellect was much more in evidence in those days than in any other?

The comparison between the emotions of man and the instincts of lower animals

In fact, everyone who has ever written a sentence of argument, or who has ever sought for facts in his life, knows all the time that he is moved by desire of some kind — moved, guided, prompted, checked; that it verily "forces" the facts upon him, from nature's pack, as a conjurer "forces" a card upon his patron The desire may be for money, to prove oneself right, to prove one's friend right, to prove someone else wrong, to prove the rightness of the rest of one's beliefs (a dominant motive in the highest minded), to be useful, to be cheering But there always is desire behind us all, and without it we should never stir a step, mind or body.

Let us turn now to another question. Feeling, desire, emotion — all these are words which insisted on turning up in the foregoing discussion. What, in fact, is the relation between emotions and instinct? Some relation there certainly must be. In still recent years, and even now in the estimation of those who have not followed the advance of psychology, the emotions of man corresponded to the instincts of the lower animals. The view was, of course, that man had very few instincts; little, indeed, besides the reproductive instinct — whence, by a train of morbid and childish association, the idea that instinct in general is something "low" and unworthy of man — and hence, when the evident resemblance between an angry man and an angry dog was observed, it was necessary to assume that the dog was acting — low hound — under the influence of instinct, while the man was moved by emotion

A little honest thinking will suffice to show that there is something wrong here; and perhaps we should be nearer the truth if we dropped the assumption that the man and the dog are so utterly different, the man a "reasoning being" and the dog a mere dog, the one being guided by his Godlike intelligence and the other by its animal instincts. Indeed, we shall see in a moment how certain and evident is the truth when we do.

What the most delightful of all writers on psychology taught

But first, for the sake of the historical interest and also on account of its general acceptance by the mass of amateur psychologists today, let us look at the theory of the emotions which was independently advanced by William James and by the German writer Friedrich Albert Lange, many years ago, and which is therefore technically known as the James-Lange theory of the emotions. Beyond dispute, Professor James was the most brilliant, easy, irresistible and delightful to read of all writers on psychology. He had "a way with him" which no one could resist. Every psychologist is immensely indebted to him for his ideas, his *élan*, his fertility of illustration, and the enhanced interest which one felt in every subject which he handled. Never was man better suited for the advocacy of a brilliant paradox; and there can be few readers of psychology who have not been to some extent under his spell, above all in the case of his theory of the true nature of emotional actions and the true order of events therein.

According to this theory, which, at the time of its advancement, made a great sensation in psychological camps, we are all quite wrong when we think that we cry because we are sorry, or tremble and run away because we are afraid. That, according to James, reverses the true order of events. In point of fact, we cry or tremble instinctively, by "compound reflex action", and *then* we become conscious of the trembling, or the wet tears, or the palpitating heart, or the fleeing limbs, and this consciousness of the organic changes in our bodies is the emotion. We do not cry because we are sorry, or run away because we are afraid, but we are sorry because we cry, and afraid because we run away — or, even if we do not run away, because we feel the beating heart, the over-acting muscles of respiration, the dryness in the throat.

Thus, in Professor James Ward's words, "Professor James's main position is that an emotion is but a sum of organic sensations".

Objections to the James-Lange theory of emotional action

This is, to some extent, a theory which is capable of being put to the proof, and the evidence is against it. Professor Sherrington, of Oxford, a leading student of response, found that, after the performance of an operation which prevented impulses of internal origin from reaching the brain, dogs still exhibited the symptoms of emotion when their instincts were excited.

The facts are against the James-Lange theory, but we can all of us see that there is something in what the theory asserts. It is true that one's feeling of wet tears, a grimacing face, one's hearing of one's own sobs, contributes to the feeling of being very sorry for oneself. It is true that discomfort is increased by palpitation, and that when you run away from a noise in the dark you are more frightened than ever. It is profoundly true that, if we apply the James-Lange theory to our own conduct, we profit thereby Put on a smiling for a depressed and drooping face, speak in a cheerful instead of a miserable voice, and you feel better. The hysterical woman, on the contrary, who was doing very well until her doctor or her husband entered the room, now speaks as if she were nearly dead, and looks as ill as possible, in order to excite the sympathy upon which she lives, and the immediate result is that she feels ill, and, in fact, is ill in some degree These, and a hundred other instances, show that sensations from the body do contribute notably and importantly to our emotional state; and for the clear perception of this we are all indebted to the authors of this celebrated theory, but no more can now be said of it.

The probable play of emotions through an emotional center in the brain

The fact, no doubt, is that our emotions have a central seat, with contributions from the various parts of the body, although no research into the functions of the *cortex cerebri* shows any trace of an emotional center there. Nor need we be surprised, if we are at all prepared to believe the truth known to every lover of animals — that they have emotions like our own. The emotions must have their central seat in some old-established part of the brain The Italian student Pagano has added much evidence in favor of the view that the "basal ganglia" of the brain, the great and ancient masses of nervous matter which occupy the base of the cerebrum, are the seats of the emotions

And now we come to the simple but all-important question, What is the true relation of emotions, which are supposed to occur in man (because he knows he feels them), and instincts, which are supposed to be the peculiar characteristic of the lower animals?

Emotion the subjective aspect of an instinctive action

The truth, as Dr. McDougall was the first clearly to perceive and to prove, is that no such distinction as is commonly asserted exists at all. The facts are just the same in a man or in a dog. We can see inside ourselves, we have first hand knowledge of our own consciousness, and introspection instantly detects what we call emotion there We cannot see or feel the emotion of a dog; we only see its instinctive actions. As for our own actions, they are so largely modified in char acter by our intelligence that their fundamentally instinctive character is commonly overlooked. Now, we have only to put two and two together. Man has emotion and instinct, and so has the dog In both the emotion is simply the subjective, internal, psychological aspect of the objective, external, physiological performance or process which we call an instinctive action. But the two are really one and the same thing, with its double aspect, and henceforth they must be studied together, for they are inseparable, and neither can be understood without the other.

This theory of emotion as simply the "affective" or "feeling" side of instinct has now definitely superseded the James-Lange theory of emotion and all others It was first briefly stated by Dr. McDougall in 1905, though, as he points out, William James and others came at times very near to it.

Probably Dr. McDougall's advantage lay in his biological and medical training, which made it impossible for him to accept such distinctions between the fundamental facts of, say, man and the dog, as we have already quoted and repudiated. In very terse but complete form, the theory, as later defined by its author, runs as follows: "Each of the principal instincts conditions, then, some one kind of emotional excitement whose quality is specific or peculiar to it; and the emotional excitement of specific quality that is the affective aspect of the operation of any one of the principal instincts may be called a *primary emotion*."

Directly we apply this theory it works like magic. At once we can begin to form great pairs of instincts and emotions which largely dominate the life and constitute the mind of man — the instinct of flight and the emotion of fear, the instinct of repulsion and the emotion of disgust, the instinct of curiosity and the emotion of wonder, the instinct of pugnacity and the emotion of anger, the parental instinct and tender emotion, and more besides. These are the real architects and constituents of man, of his behavior, his institutions and his societies.

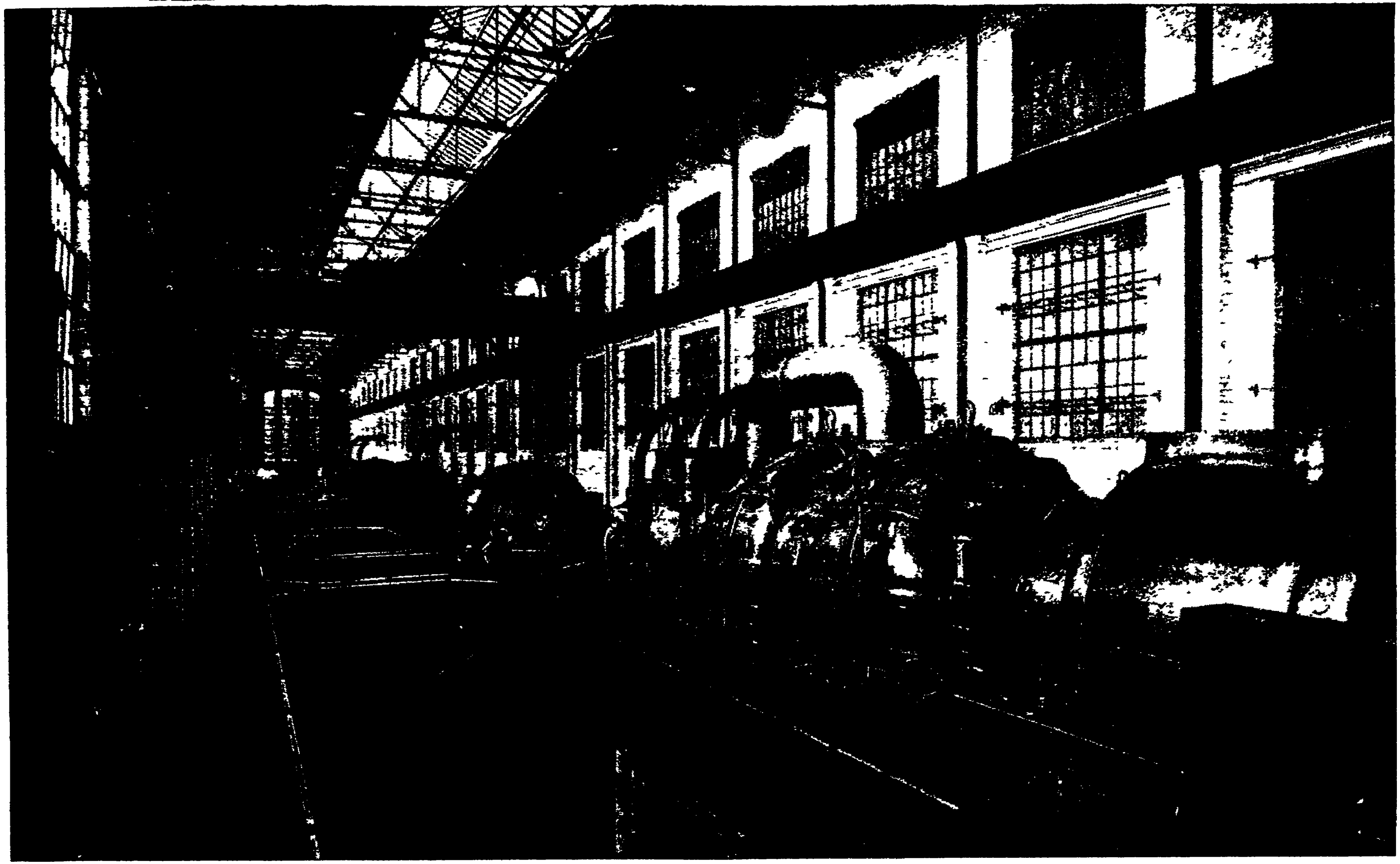
He may call himself the reasoning creature, if he will, and, in so far as his intelligence is almost or quite his most distinctive characteristic, no doubt he is entitled to do so. But if he thinks that his intelligence moves him, is the spring, the motor of him, he talks nonsense. It is merely an instrument, used in the service of the instincts, just as habits are formed in their service. "Mankind is only a little bit reasonable, and to a great extent very unintelligently moved in quite unreasonable ways. By all means let us be moved in only reasonable ways, but, even so, reason is not the mover. In truth, men are moved by a variety of impulses whose nature has been determined through long ages of the evolutionary process without reference to the life of men in civilized societies."

The problem for mankind is not, as many Eugenists suppose, to get more "ability" into the world. The problem is to adjust a creature such as man, moved by his instincts for what, in our moral judgment, we call "good" and "evil" both, to the needs of social life, and to the demands and the restrictions, the gains and perhaps the losses, which that implies. The tragedy of the world is not the lack of ability, which is merely power, like dynamite, but the terrible "disharmony", more serious than anything Professor Metchnikoff writes about under that name, between the various instincts of any man, and only too often between their upshot in conduct and the highest needs of mankind.

If these supreme and colossal problems are ever to be solved — which has been the task of society, of religion and law, and custom and institutions and government in all ages — we must seek ever deeper and truer understanding of its factors within the instinctive and emotional nature of man. Therefore it is to closer study of the greatest of these factors that we must now proceed.

MUD-WASP INSTINCTIVELY PREPARING FOR ITS PROGENY

ELECTRICITY IN THE MAKING TO SUPPLY A GREAT CITY



Courtesy Commonwealth Edison Co
The turbine room in one of the large power stations of the Commonwealth Edison Company in Chicago. The total power generated in these ten turbines is 120,000 kilowatts

POWER OVER DARKNESS

The Battle between Gas and Electricity and the Marvels of Modern Illumination

THE CHEAPENING OF ARTIFICIAL DAYLIGHT

SO great a power has man already obtained over the gloom of night, that if the electric furnaces working at Niagara Falls were combined into one white glow, the radiance could be seen from the moon. Possibly the whole electric power obtainable from the vast waterfall might be transformed into a signal fire that would be visible from Mars.

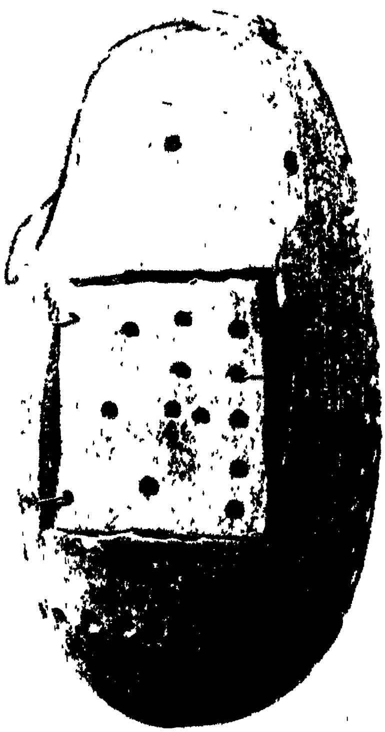
Yet a hundred and fifty years ago the civilized races scarcely had any stronger means of overcoming darkness than those possessed by savage and barbaric peoples. In the days of Shakespeare the lighting of both palace and hovel was exceedingly primitive. The guttering of rush lights, and the splutter and smell of faint lamps fed with animal fats, made a court festival at night a dim and not altogether pleasant affair. Indeed the world could show but little advance upon the methods of lighting invented by some ingenious cave-dweller of the Age of Stone. He used a small, shallow lamp, filled with animal fats, in which was placed a bit of dry wood or a wisp of grass that served as a wick. Even the Romans, in the days of their power, had a somewhat similar lamp of burnt clay, holding a little fish oil or animal oil. Our forefathers hunted the whale chiefly for lamp oil, and many of our coast towns owed their early prosperity to their being centers of the sperm oil industry. The Chinese, from time immemorial, had kept their picturesque lanterns alight by means of oil crushed from vegetable seed; but it was only towards the middle of the eighteenth century that colza or rape-seed oil, obtained from the wild cabbage, began to be largely used for lighting purposes.

The lamps, however, in which the new oil was burned remained quite primitive in construction until Aimé Argand, a Swiss, discovered a way of supplying air both inside and outside by means of a hollow burner into which a tube-shaped wick was fitted. The increased supply of air to the burning flame brought about a stronger and quicker combustion, with the result that the light became clearer and brighter.

It is impossible to understand the frame of mind and the social condition of both the savage and civilized races of the past unless regard is had to the feeble power over darkness that the whole of the human race then possessed. When this planet of ours turned away from the light of the sun, and swung out into the mystery and darkness of interstellar space, strange and horrible powers seemed to sweep in upon the earth. Anybody who as a child has walked alone along a dark country road on a windy night will remember the primitive superstitions that then assailed him. Ghostly forms crouched amid the bushes, uncanny things whispered and moaned and glimmered in the fields, the trees and the hedgerows. These fears of the night have always haunted man. Most probably they were based at first upon the terror of nocturnal beasts of prey; but when the early savage discovered a method of guarding himself from bodily enemies by means of a camp-fire, lighted with a fire-drill or sparks from a flint, the awful gloom around him still worked on his mind and imagination, so that he peopled the darkness with spirits of dread and horror.

This extraordinary superstitiousness in regard to the imaginary terrors of the night

has been responsible for much of the delay in the evolution of the clear, rational constructive powers of the human mind. Men were fairly reasonable in broad daylight, but when night fell their primitive fears awoke, and the old superstitions resumed somewhat of their ancient sway over the imagination. It is not very long since the traditions of the dark ages entirely lost their power over the minds of the larger number of civilized people. Even Francis Bacon, the apostle of experimental science, believed in the existence of the evil spirits of darkness, and looked upon them as legitimate objects of study. It is not too much to say that the greater part of the cruel, sanguinary mind-deadening practices and ideas in primitive and pagan religions were engendered by man's terror of darkness.



Courtesy National Lamp Works of General Electric Co

UTILIZING THE SECRET OF THE FIREFLY

The West Indian native illuminates his pathway by a perforated gourd filled with hundreds of fireflies

Probably there have never been wanting bold criminals who, playing on the general fears, used the darkness to do wrong to their fellow-men. Only by bearing in mind how ill-lighted were the streets of European cities in the eighteenth century, and how dark and deserted were the towns and villages on the country roads at night, can we understand the social conditions under which the footpad and highwayman pursued their nefarious business practically unmolested. Even important city thoroughfares were avenues of gloom. The few dim street-lamps that occurred at intervals were merely put up as guides to enable the belated wayfarer to find his way from point to point.

From the earliest times the existence of inflammable gases escaping from the bowels of the earth was known, and, as early as 1739 a paper was presented before the Royal Society describing the production of a similar gas by the combustion of coal in a closed vessel. But it was not until 1792 that William Murdock, a Scot, demonstrated the value of coal gas as an illuminant by lighting his house and office in Cornwall. He moved to Birmingham in 1798 and there lighted the Soho foundry with coal gas. This successful experiment did much more than provide a new luxury for the civilized world It was one of the greatest advances ever made in discouraging and preventing crime. Light is cheaper than the police.

There are other inventions, such as the railroad, the steamship and the telegraph, which have had a great effect upon economic conditions of the world. But the discovery of cheap and abundant sources of powerful artificial light has removed one of the chief opportunities of the criminal. It has saved the sailor from shipwreck and the railroad traveler from collision. It has turned for many a worker the short, dark days of winter into as prosperous a period of employment as the long, bright days of summer. And it is artificial light of great intensity, used in the microscopic examination of microbes, that has helped to defend mankind against the germs of disease, and illuminate some of the subtlest problems in other branches of science.

So we must put these, and other advantages obtained from an increasing control over the artificial sources of light, against the modern follies of the luxurious class that turns night into day, and against the blinding misuse of electric lights in garish, revolving advertising signs. It is quite true that we are now living in an age of glare. Even in many private houses artificial light is abused rather than used. It is possible that more eyes are now weakened by the employment of too strong and dazzling an illumination than by poor and feeble lighting. But a new class of professional men — the illuminating engineers — are now generally consulted by architects in the construction of every kind of building. They have reduced to a science the relation of light to the human eye, and are able to arrange artificial lighting in a way that makes all work done by it more healthful and more comfortable, with what the reformers contend will be a marked and permanent improvement in the powers of vision in the younger generation.

But the work of the inventors is not completed. No means have yet been discovered of transforming energy into light in a really economic way. The very best of modern lamps, scientifically speaking, is little more than a makeshift. The civilized world is like the Chinese boy in Charles Lamb's fantastic story about roast pig. The boy was the first discoverer of the delights of cooked meat, but his only way of cooking it was to burn down his father's house, so that the pig should be roasted in the flames.

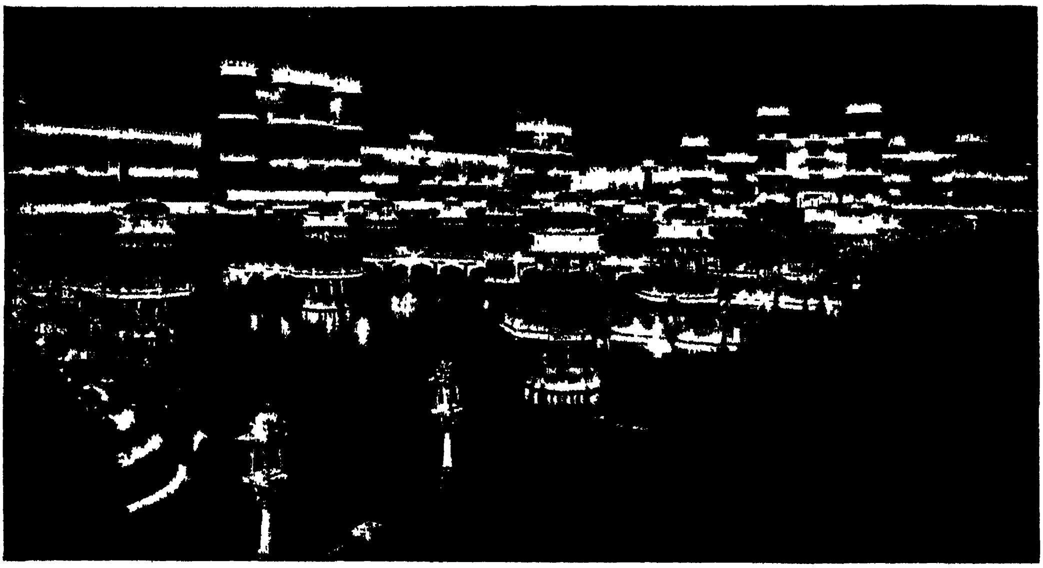
JAPANESE LANTERNS IN A STREET IN TOKIO

Our ways of producing artificial light are almost as primitive. Neither gas nor electricity is yet used in an efficient manner. We take something and make it very hot, though heat is the very thing we do not wish to create. Still we make it very hot, often using about 99 out of 100 parts of energy in generating wasteful, unwanted and injurious heat. So we go on until the thing gets white-hot and begins to shine. Then, like the Chinese boy we think we have performed wonders.

This process of producing light by heat is known as incandescence. In the customary electric filament lamps, for instance, an electric current is forced through a metal wire that strongly resists the passage of the electricity. All the energy expended in forcing the current through the wire is transformed into heat, and the wire is made at last so hot that it shines. In an ordinary way the wire would quickly be burned up, just as the wick of a lamp is. But the combustion is prevented by pumping the air out of the glass globe, so that little or no oxygen remains to combine with the metal of the wire and burn it away. In the latest type of electric lamp the evaporation of the tungsten filament is counteracted by filling the glass bulb with an inert non-combustible gas such as nitrogen or argon.

It was mainly due to the work of Thomas A. Edison, in 1878, and J. W. Swan, in 1879, that the incandescent electric lamp was developed into a practical success. Edison first employed a platinum wire, but later had the much happier idea of using a carbon filament. He treated cotton thread with sulphuric acid, and obtained a parchment-like substance which was fairly durable. The modern carbon filament is made from cotton-wool that is first dissolved in some solvent and then formed into a long, semi-transparent thread that looks somewhat like catgut.

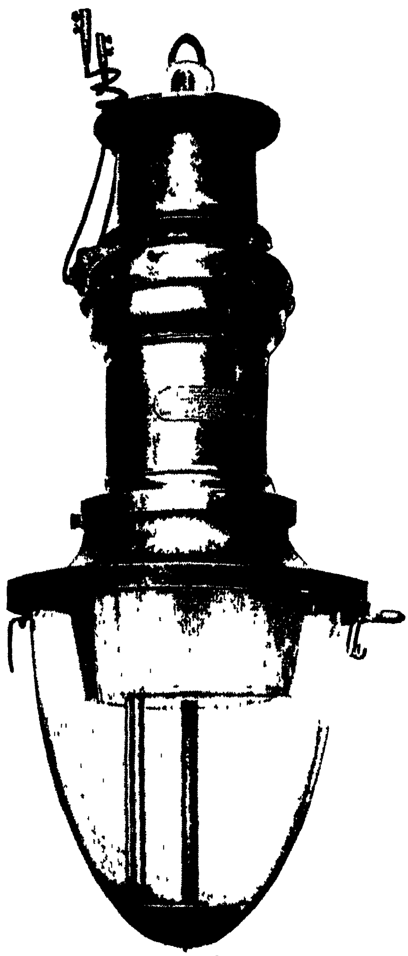
In an attempt to find some substance that would endure heating to a higher temperature than the carbon filament, Edison and others began to experiment with various kinds of rare earths, such as thorium and zirconium. But it was found that no mixture of any of these earths and carbon was permanent. So they bent their energies to the task of making the carbon filament lamp a handier and brighter and more efficient means of lighting than the gas jet that had become the common light of the civilized world.

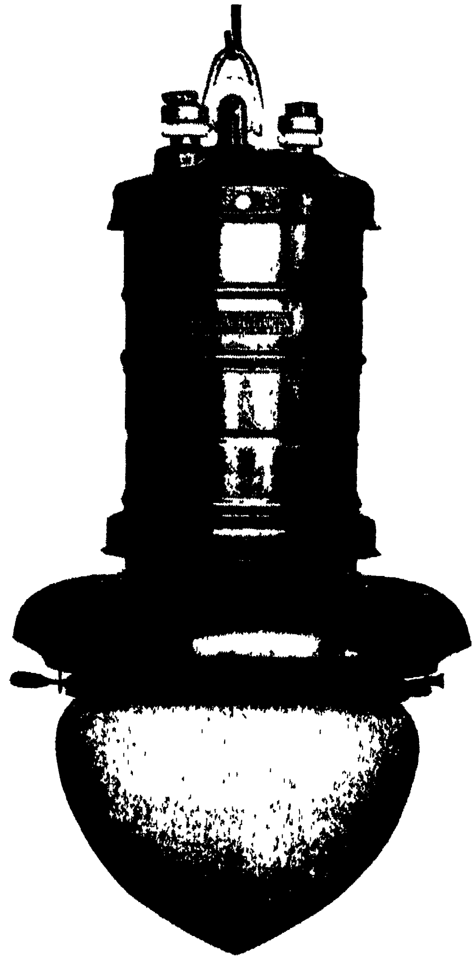


DECORATIVE VALUE OF ELECTRIC LIGHT — A SCENE IN THE FRANCO-BRITISH EXHIBITION OF 1908 WHEN THE CARBON FILAMENT STILL PREDOMINATED

In 1879 Edison gave a public demonstration of his incandescent lamp by lighting houses and streets in Menlo Park, N. J. The *New York Herald* devoted an entire first page to this demonstration and it was found necessary to run special trains to accommodate the crowds. In 1880 the first electric lighting system on shipboard was installed on the *Columbia*. One of its original dynamos is exhibited at the Smithsonian Institution.

For some years the victory of the electric lamp seemed to be inevitable. Year by year improvements were made in the manufacture of the electric bulbs and in the





Courtesy General Electric Co

MODERN ARC LAMPS

A LUMINOUS ARC LAMP

The arc plays from the upper solid copper electrode to a lower electrode which consists of a thin steel tube packed with a mixture of magnetite, titanium oxide and chrome iron This lamp is well adapted to the lighting of city streets as its light is thrown out over a very large area

A FLAME ARC LAMP

Both upper and lower electrodes are of carbon impregnated with substances which give the lamp a high efficiency. Calcium fluoride, most frequently used, causes the lamp to give a yellow light; cerium chloride a white, and strontium chloride a pink light The lamp is best adapted to advertising and the lighting of public squares.

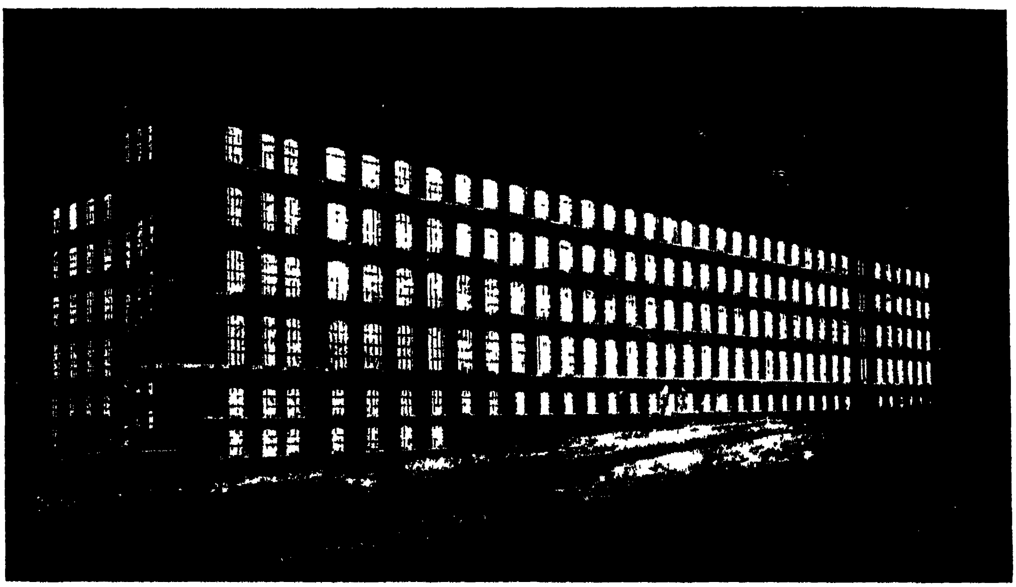
method of supplying electric power in a large way, to private houses and big buildings; and though the powerful gas companies began by ridiculing the new illuminant, the time soon came when electric lighting seriously threatened to displace gas lighting The cost of gas in the ordinary batswing burner was nearly forty cents for a thousand candle-hours. The early form of glow lamp, on the other hand, produced its light at an expense of under thirty-five cents for a thousand candle-hours. More important still, in the lighting of great buildings and large outdoor spaces, was the progress being made in the electric arc lamps. The closed arc lamp produced light at last for thirty cents a thousand candle-hours, while the flaming arc lamp created the same amount for about five cents.

So matters were proceeding in the battle between electric light and gas light. In the meantime, however, a young Austrian, Auer von Welsbach, took up the study of the rarer earths that Edison had abandoned. He built on a discovery made in 1835 by Captain Thomas Drummond. Drummond knew that the light-giving quality

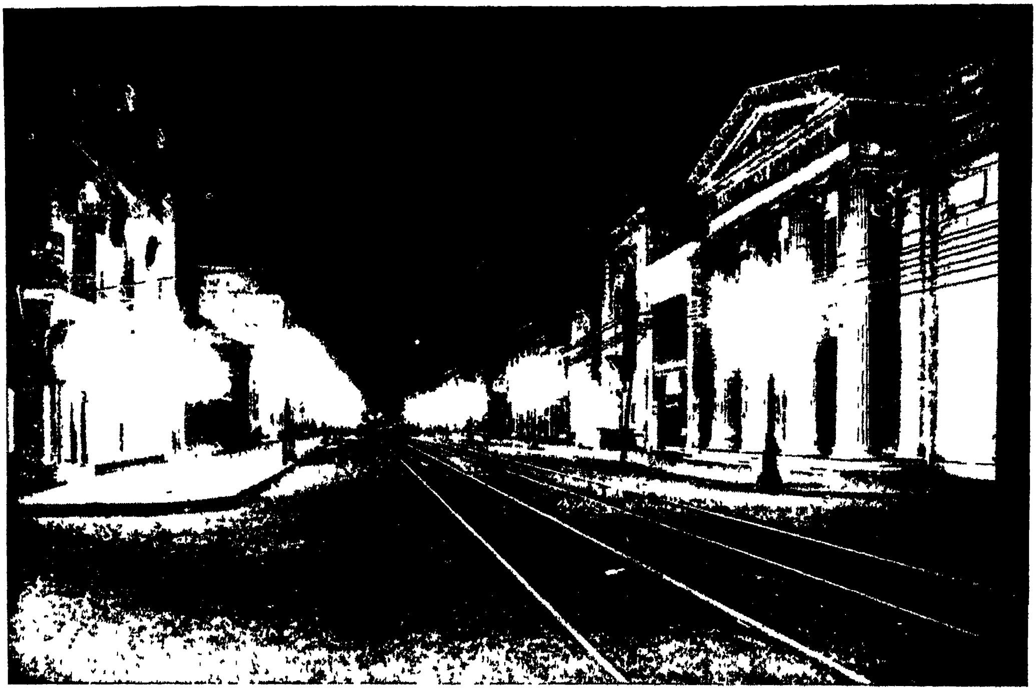
of gases depended on the carbon brought to incandescence in a flame. For in the absence of carbon, as when a jet of pure hydrogen was burned, extreme heat was produced without any light whatever Drummond introduced the needed solid body into a burning jet of hydrogen, by means of a block of compressed quicklime Thus was invented the Drummond lamp of intense limelight still used in theaters.

Now, the rare earths resemble lime in their effects upon the radiancy of gas. This was why Welsbach, in 1880, began his researches into the same strange substances as the inventors of the glow lamp had experimented with. In order to ascertain their value as illuminants, the young Austrian chemist brought to melting point one specimen after another of the rare earths on bits of platinum wire. In each case the experiment was remarkably unsuccessful. Little beads of the earths formed on the wire, and instead of improving the quality of the light the beads only dimmed it. Most men would have given up the matter on obtaining this very disappointing result, but Welsbach was inspired by his disasters; and there came into his mind an idea of that golden quality that only an inventor of genius hits on. He saw that the very thing that had made the rare earths unsuitable, when combined with the cotton filament of the electric glow lamp, would be successful in a gas burner For in the gas flame all the carbonized cotton would be quickly burned away, and the rare earths would remain. So he wove a mantle of cotton thread, and soaked it in a solution of one of the rare earths, and dried it and put it over a Bunsen gas burner. The cotton at once burned away, leaving a mantle of earth that increased the light-giving quality of the gas in a wonderful manner

The young inventor, however, had not come to the end of his troubles His marvelous mantles crumbled to pieces in a few days; so he mixed the earth with another substance that would not fall to pieces so easily, and after six years of laborious research and experiment he made a better mantle. The extraordinary efficiency of the new means of gas lighting naturally attracted wide attention Several companies were formed for the manufacture and sale of the mantles. In a year or two, however, all these companies were on the verge of ruin. People at first bought the mantles with eager delight; it seemed that gas had suddenly and completely triumphed over the electric filament lamp. But, unhappily, the mantles were



INDUSTRIAL VALUE OF THE NEW ILLUMINANTS — A FACTORY AT NIGHT AS BRIGHTLY LIGHTED AS BY DAY



NIGHT PHOTOGRAPH IN CHURCH STREET, NEW HAVEN, CONN.

Courtesy General Electric Co

NIGHT PHOTOGRAPH IN SALT LAKE CITY, UTAH

Brilliantly lighted streets where luminous arc lamps are mounted on ornamental pedestals.

still very fragile. So numerous and costly were the breakages that the public returned to the use of the new electric light, or contented themselves with the ordinary dim but steady gas flame.

Welsbach vainly strengthened his mantle with new and stronger earths. Business did not develop, and the mantle companies thought of closing down. An

Courtesy General Electric Co.
ORNAMENTAL LUMINOUS ARC LAMP FOR STREET LIGHTING

accident abruptly converted them into one of the most prosperous of modern undertakings. At this time Welsbach was using the rare earth thorium in his mantle. Going into a factory, he chanced to find a bit of raw thorium oxide. He set to work on this then scarce and rare earth, in the hope that by purifying it thoroughly he would obtain a substance that would increase the light from the gas mantle. But when the purification process was completed and a mantle made of thorium, the light fell off in an unaccountable fashion. What could be the matter? It looked as though some valuable element had been cast aside in the process of purification. A series of new researches showed that it was a minute quantity of cerium which provided the valuable element.

Here was a discovery of the highest importance. It put a new complexion on the battle between gas light and electric light. As the result of many experiments it was found that one part of cerium and ninety-nine parts of thorium oxide were the best proportions of the earths used in the making of gas mantles. Why these proportions are the best, nobody knows, but the happy discovery of them, in 1890, changed the fortunes of all the gas companies throughout the world. The cost of gas lighting dropped from nearly forty cents a thousand candle-hours to something well under seven cents. This compared very well with the thirty-five cents a thousand candle-hours of the electric glow lamp of the second class and the twenty-five cents cost of the same amount of illumination from the electric lamp of the first class. Gas was victorious.

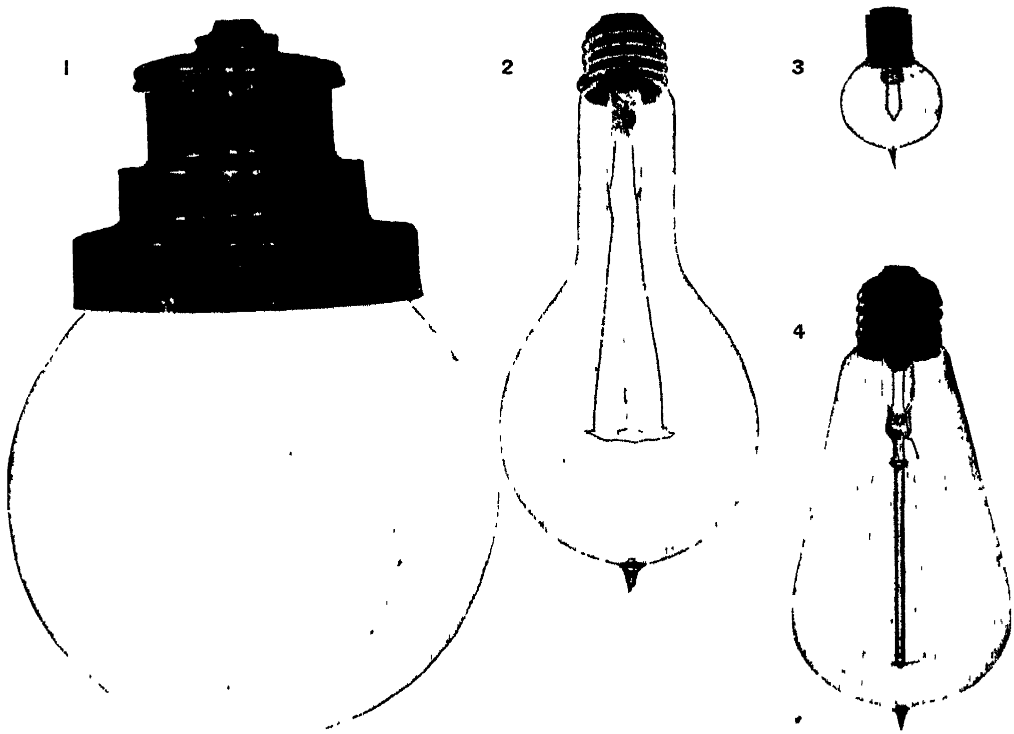
But the inventors of electric light were not idle. Indeed, Welsbach himself joined their ranks, after bringing his gas mantle to its present perfection. The problem was to find something at once stronger than the carbon filament and more resistant to the passage of electricity. It was clear that a metal was wanted. So men began to throw themselves into the study of rare metals with the same eagerness that they had pursued the study of the rare earths. Welsbach was first in the field with the osmium lamp, which was put on the market in 1904. Osmium is a rare metal found in the ores of platinum. When burned in the ordinary way, it combines with the oxygen of the air to produce a pungent and dangerous vapor. In the vacuum of an electric bulb, however, there is no oxygen for it to combine with. The osmium lamp cut the cost of the electric light nearly in half.

But — such are the vicissitudes of modern invention — the year after it was put on the market a more efficient glow lamp appeared with a filament of tantalum. Invented by Werner von Bolton, the tantalum lamp was nearly one-fifth more powerful than its rival Then came, in 1905, the discovery of a still more efficient filament of rare metal

Amid the waste of scores of mine dumps was a heavy, steel-gray substance for which no use was found The Swedes gave it the name of "tungsten", that meant "heavy stone". This waste and apparently useless stuff has now become one of the most important things in the world. Combined with steel, it forms the cool, cutting edge of the high-speed tools — lathes, drills, planers and so on — that work at a pace which has revolutionized the great metal industries. And now tungsten is well on the way to become one of the chief light sources of the world.

At first there was a battle for supremacy in the electric lamp between tungsten and tantalum. Tantalum used to be thought one of the hardest of metals. In his early experiments von Bolton found it impossible to bore a hole through a sheet of tantalum only one-twenty-fifth of an inch thick. But by refining the metal in a powerful electric arc he reduced its strength to that of hard steel, when he was able to roll it into the thinnest of thin sheets and draw it into the very finest of fine wires.

By this means Von Bolton was able to make a strong, wire-drawn filament, and the tantalum lamp in which it was used was more than twice as efficient as the carbon filament lamp. What was of great practical importance, its length of life was extraordinary. Moreover, rich masses of tantalum were discovered in Australia, so that the new lamp promised to become quite as cheap as the ordinary lamp.



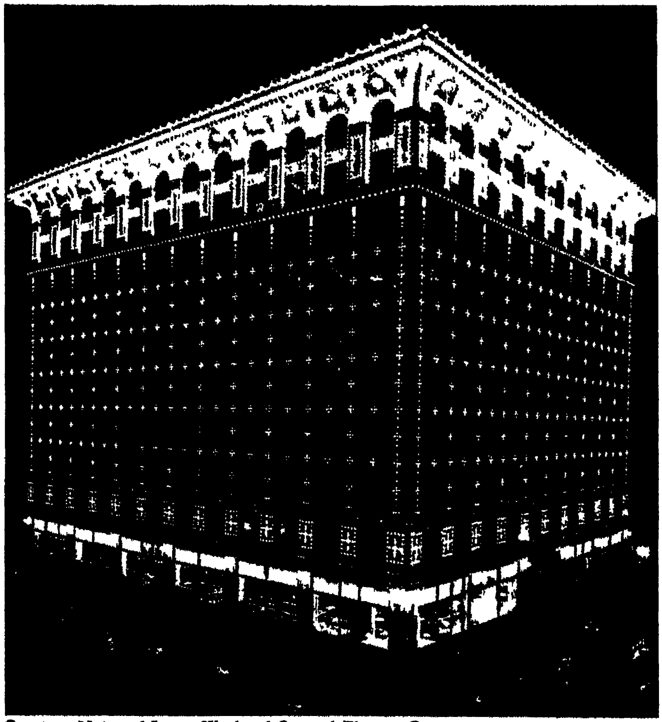
Courtesy Edison Lamp Works of General Electric Co.

MODERN INCANDESCENT LAMPS

1 Lamp unit containing a 1000-watt gas-filled lamp used in store and theater front lighting.
2 100-watt gas-filled lamp (Mazda, type C)
3 Automobile headlight, gas-filled (Mazda, type C)
4 60-watt vacuum lamp (Mazda, type B)

1 is shown about one-fourth, 2–4 about one-half their real size.

Tungsten produced a better light than tantalum, and it was half again as efficient. It could do with one unit of electric energy what tantalum needed one and a half units to perform But the trouble was, tungsten was so excessively hard that it could not be drawn into wire in the ordinary way So it had to be dissolved and converted into filaments by deposition, and unfortunately the tungsten filament thus made was very fragile The tungsten lamp was so brittle that it could not be transported over a long distance, and naturally it was liable to swift destruction even when it was fixed in a house. But this great difficulty has now been overcome. Tungsten has been drawn into wires and built into a lamp of great strength and wonderful lighting power. It produces one of the whitest lights, and it is more than three times as efficient as the ordinary electric glow lamp. By means of it the electric bulb light has been developed to something like practical perfection. All that is now needed is an abundant supply of tungsten and improved methods of manufacture to cheapen the market price of the new lamp. Already tungsten has been found in large quantities in many parts of the world.



Courtesy National Lamp Works of General Electric Co

THE ILLUMINATION OF AN OFFICE BUILDING IN DENVER

This is called " the best lighted building in the world "

It was at one time thought that the wonderful economy of the new lamp would bring about an increase in the price of the electrical current. Electric supply companies, it had been said, would have to raise their rates in order to make a reasonable profit on the diminishing consumption of electricity. There has been, instead, a decrease in the price of electric current. The new tungsten filament has instigated a more general sale of electrical current. Now that better and cheaper electric lighting is possible, the use of the new invention will continue to spread and the consumption of electricity will be still more largely increased.

It must be remembered that the electric lighting companies are still engaged in the battle of illumination with the gas companies. Any increase in the price of electricity would be disastrous for the electrical interests At present the two forces seem to be about equally balanced. Electricity has its advantages, gas has its advantages; and not till the next invention of importance cheapens to an appreciable extent gas or electricity, will the long rivalry between the two kinds of light be decided.

The electricians certainly possess some very promising forms of lamps that need only an apparently slight improvement to come into large or even general use The flame arc lamp, for instance, is much more efficient than either the tungsten lamp or the mantled gas burner. It gives, as we have said, light for a thousand candle-hours at the low price of five cents.

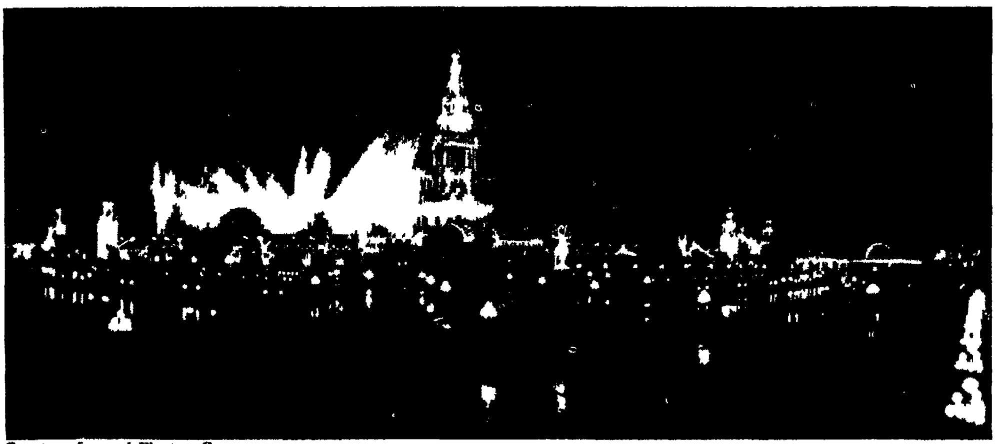
It is based upon the very oldest invention in electric lighting. In 1746 Bishop Watson produced a beautiful arch of flame

between the points of a U-shaped tube, placed in a vacuum globe. In 1801 Humphry Davy made an arc between two carbon poles. Other men of science improved on these experiments, but these achievements were of real interest only to such.

What was first required to make any kind of electric lighting practical was the invention of a means of turning mechanical energy economically into electrical power. Faraday found the principle of the dynamo that does this; and in 1870 the Belgian, Zénobe Théophile Gramme, brought out his famous dynamo that transformed electricity into one of the master-forces of civilization. It then became easy to make electric arc lamps by sending a steady and powerful current leaping across one carbon point to another. Then, by enclosing the arc in a nearly air-tight inner globe, the rate of consumption of the carbon was greatly reduced, and much of the cost and labor of renewal was saved. More recently came the invention of the flaming arc lamp. The carbons were impregnated in preparations of lime or in the salts of certain other substances with light-giving qualities. The arc then became a veritable flame of light, the radiance coming from the arc itself, and no longer from the glowing tips. In this way an enormous increase of light was obtained. Unfortunately, the flaming arc lamp often gives off an undesirable vapor, so it is chiefly useful in outdoor lighting. Arc lamps of all kinds are also less adaptable to general lighting because they can only be made in relatively large sizes.

Possibly — we might say probably — none of the lights that we have discussed is the light of the future. As a matter of fact, we have no idea whatever what the light of the future will be. Even its principle has not perhaps been yet discovered. All that we know is that the glow-worm and the firefly and the luminous creatures of the waters can manufacture in their own bodies a wonderful radiance, the secret of which science will one day reveal. We rely now on incandescence as a source of light, often wasting in heat production ninety-nine parts of energy in order to get light out of the remaining one part. In other words, we get but a cent's worth of illumination for every dollar spent. Here, then, is a fine field of activity for an inventor of genius not averse to making an immense fortune.

All that is needed is a practical method of producing light by the process of luminescence, instead of by the process of incandescence The cold, beautiful light of the glow-worm and the firefly is created with the utmost economy. Their energy is turned directly into radiance, without the production of extraneous heat. In the light produced by a firefly there is only one four-hundredth part of the heat

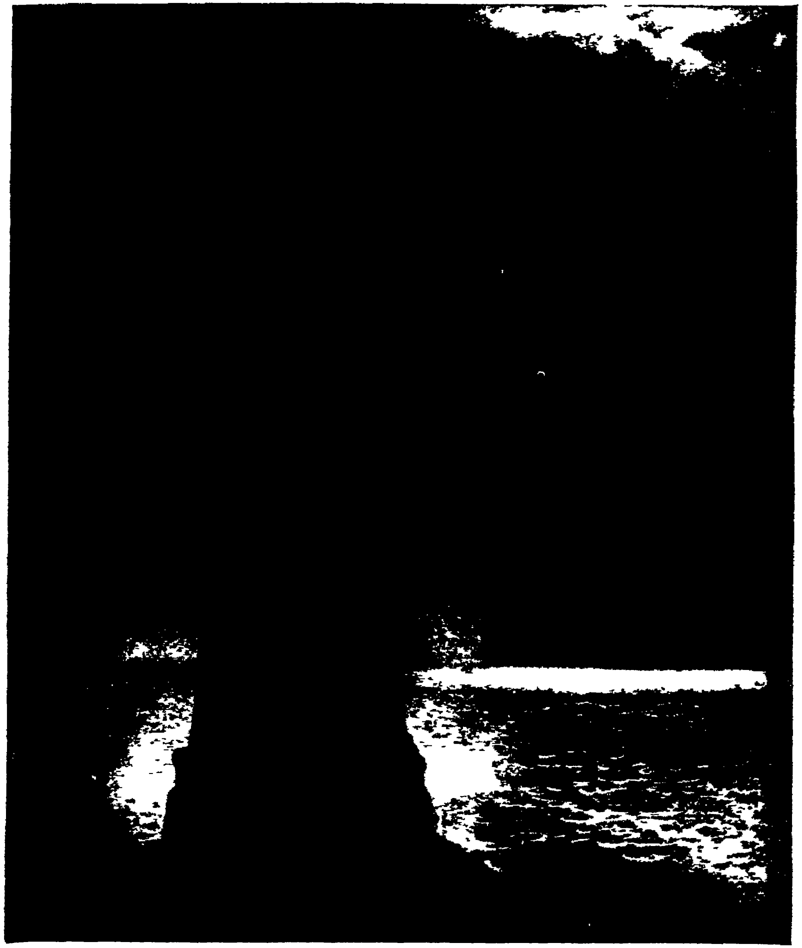


Courtesy General Electric Co

GENERAL ILLUMINATION OF THE PANAMA-PACIFIC EXPOSITION AT SAN FRANCISCO

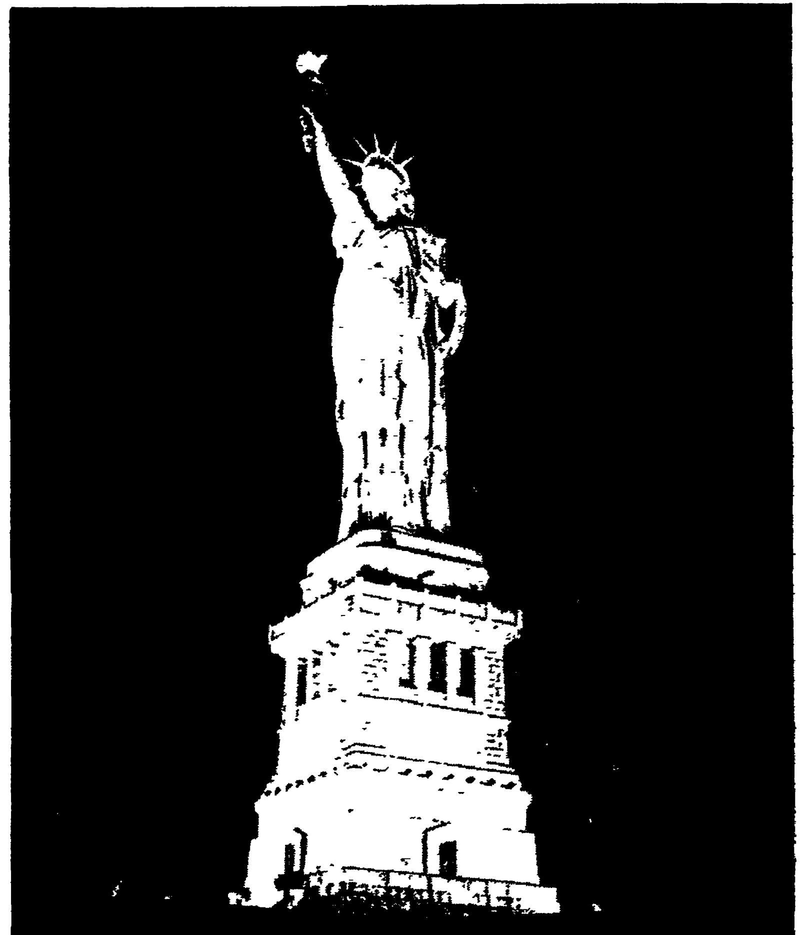
In the center stands the Tower of Jewels, illuminated by 102,000 colored lights, and to the left, 48 projectors send their fan-shaped rays into the sky with a combined intensity of nearly three billion candle power.

LIBERTY BY PALE MOONLIGHT



© International Film Service
The Statue of Liberty in New York Harbor as it appeared for thirty years, illuminated at night only by moonlight.

LIBERTY BY ELECTRIC LIGHT



Courtesy General Electric Co
The Statue of Liberty as it now appears at night illuminated by a battery of flood-light projectors.

PUBLIC UTILITY BUILDINGS THAT GLOW AT NIGHT

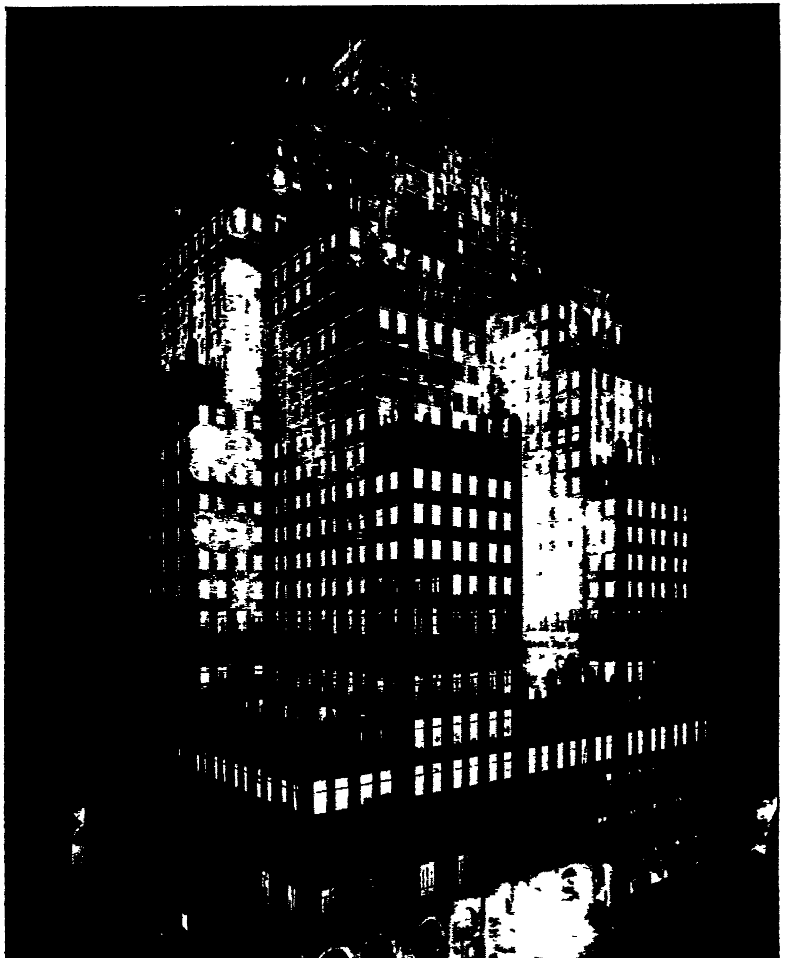


Photo Eugene Taylor

New Building of the Southwestern Bell Telephone Company, St. Louis.

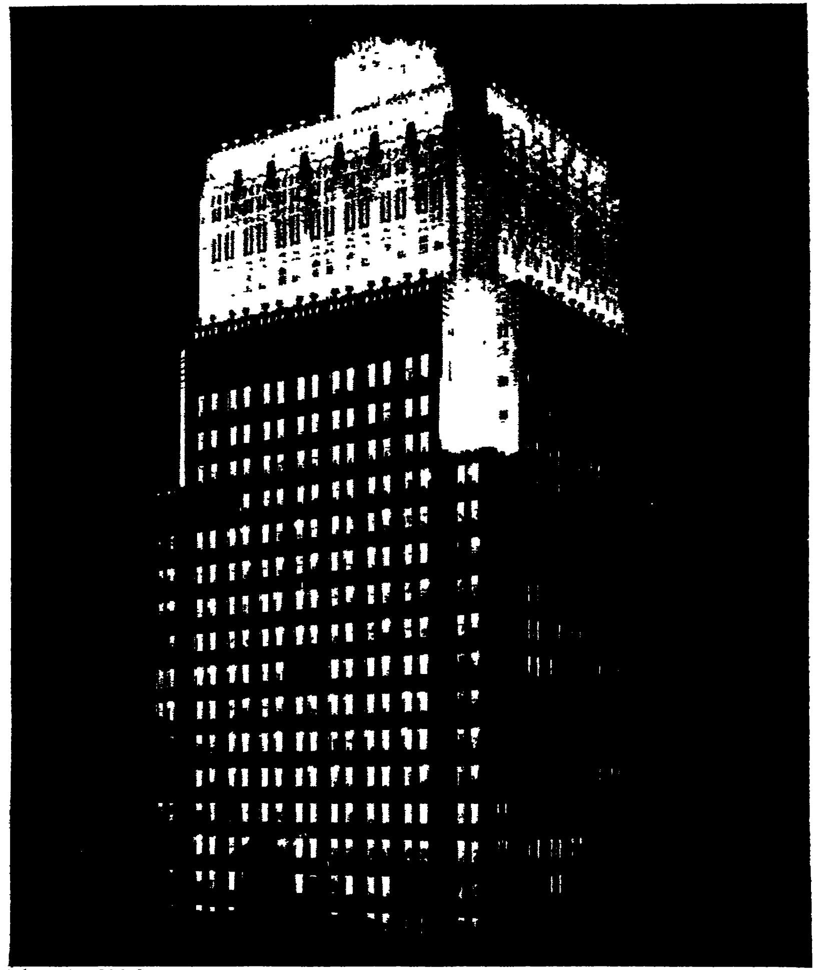
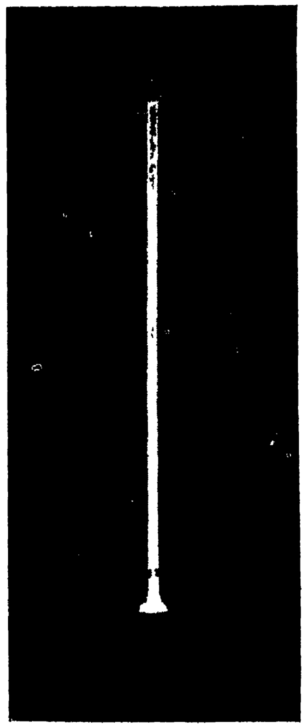


Photo by Chief Engineer's Dept

Pacific Telephone & Telegraph Company's Building, San Francisco.

associated with an equal amount of light created by an ordinary flame. As a manufacturer of light, the glow-worm is as efficient as the best of modern electro-dynamos, which is the most energy-saving instrument of power that man has invented. But the modern man of science seems to be gradually discovering a practical means of creating luminescence more brilliant than that of the little, flashing star with which the firefly conducts its courtship He empties a glass tube of nearly all its air, and then sends an electric current through the vacuum tube. By this means he excites the highly rarefied gas remaining in the tube, and sets up delicate vibrations of the atoms, without having to resort to the coarser process of setting all the molecules from the gas dancing with heat. Beautiful and soft is the glow produced by the tube; and already three remarkable lighting inventions have been based on it

The most wonderful of these three inventions is at present a light that only millionaires can afford. The strange new element neon, that Sir William Ramsay discovered in the atmosphere, is placed in a vacuum tube and excited by an electric current. The neon light is admirable; it is soft and yet brilliant, pleasing to the eyes and yet vividly clear. But as neon is at present a costly by-product, obtained in the manufacture of liquid air, it does not seem likely to come into general use. Somewhat less expensive, and yet still too dear for ordinary lighting purposes, is the beautiful artificial daylight produced by the presence of carbon dioxide in Moore's vacuum tube system. This remarkable invention is now being used in some luxurious restaurants and hotels, but the expense of the high current of electricity necessary to produce the light prevents the system from becoming popular.



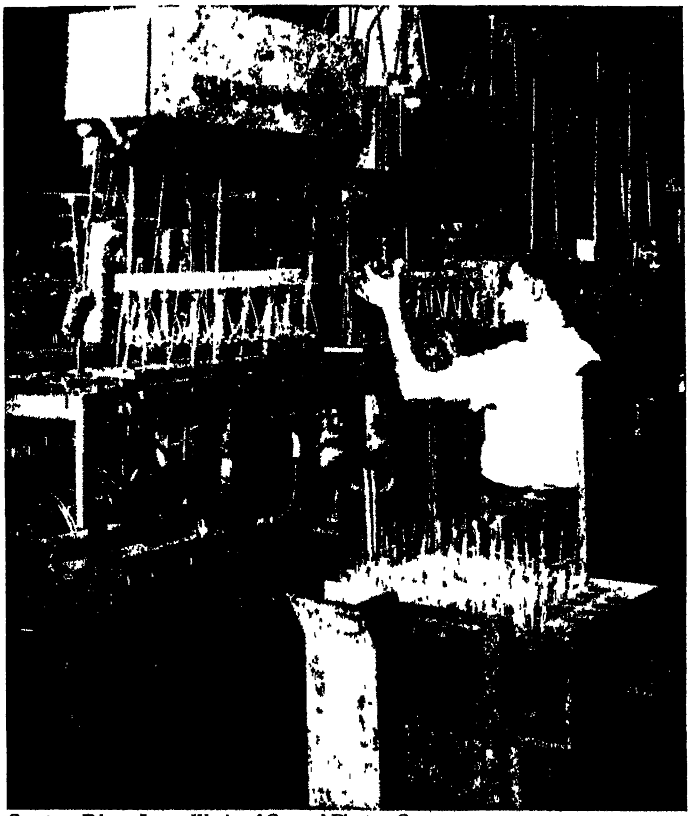
THE ORIGINAL HEWITT MERCURY-VAPOR LAMP

The heavy expenses of the neon and Moore vacuum tubes are avoided in the mercury tube lamp, invented by Peter Cooper Hewitt. The mercury lamp consists of a vacuum tube made of fused quartz or silica. In a small bulb at one end of the tube is a little mercury, which is converted by the electric current into a vapor of a peculiarly penetrating luminosity. The great thing is that the mercury is not consumed in the process of illumination; the lamp requires no attention whatever, and only a slight current of electricity to keep it alight.

Mr. Hewitt brought out his mercury vapor lamp in 1902, but a strange defect prevented it from becoming popular It was a cold light — a highly desirable thing — but not only were the heat-rays absent, but the red rays that follow next in order were also lacking The result was that the mercury light, though very grateful to the eyes, produced a curious, unearthly effect upon everything on which it fell. The faces of the spectators lost all their shades of red and took on a pale green color. Another source of trouble was that there was a dangerous quantity of ultra-violet rays issuing from the new lamp. Hewitt, however, partially overcame these various difficulties. In its latest form his lamp is fitted with a reflector that catches some of the yellow, green and ultra-violet rays and transforms them into red rays. This is done by means of a screen coated with a curious artificial substance known as rhodamine. This substance has the extraordinary power of taking the short waves of light and lengthening them out into long waves. Then, as a considerable quantity of the invisible but dangerous ultra-violet rays still issued from the quartz tube, this tube was sheathed in a case of lead-glass, which is impervious to ultra-violet radiations.

By reason of its wealth of invisible ultra-violet rays, the mercury lamp is now largely used, without its protecting glass case, for medical purposes. Cheaper, more powerful and handier than the Finsen blue light, it has a fine curative effect upon lupus and other distressing diseases. It seems very likely that when the invisible rays of the mercury lamp are carefully applied to a living organism the cells are marvelously stimulated. Hewitt took the seeds of various plants and sowed them under exactly the same conditions. Half were exposed to daylight and half to mercury light. The latter grew much more rapidly and luxuriantly.

While further improvements may be made in the art of lighting by luminescence, the most economical lamp adapted to general use at this time is the gas-filled incandescent lamp. The light from this lamp is produced by a short coil of tungsten wire raised to a temperature of nearly 3000° C. These lamps are available in various sizes ranging from 50 to 2000 candle-power and, since they do not require the attention demanded by arc lamps, the larger sizes are used extensively for the illumination of streets, exteriors of buildings and large out-door areas. The gas-filled lamps are also supplied with bulbs of bluish tinge which absorb enough of the predominant yellow light of the lamp to make the resultant light approximate the color of daylight. Such lamps may be used effectively in stores and factories, where color-matching under daylight conditions must be done after sundown.



Courtesy Edison Lamp Works of General Electric Co

PUMPING AIR FROM INCANDESCENT LAMPS

The filament would oxidize rapidly in the presence of air so that all lamp bulbs must either contain a vacuum or some inert gas such as nitrogen or argon

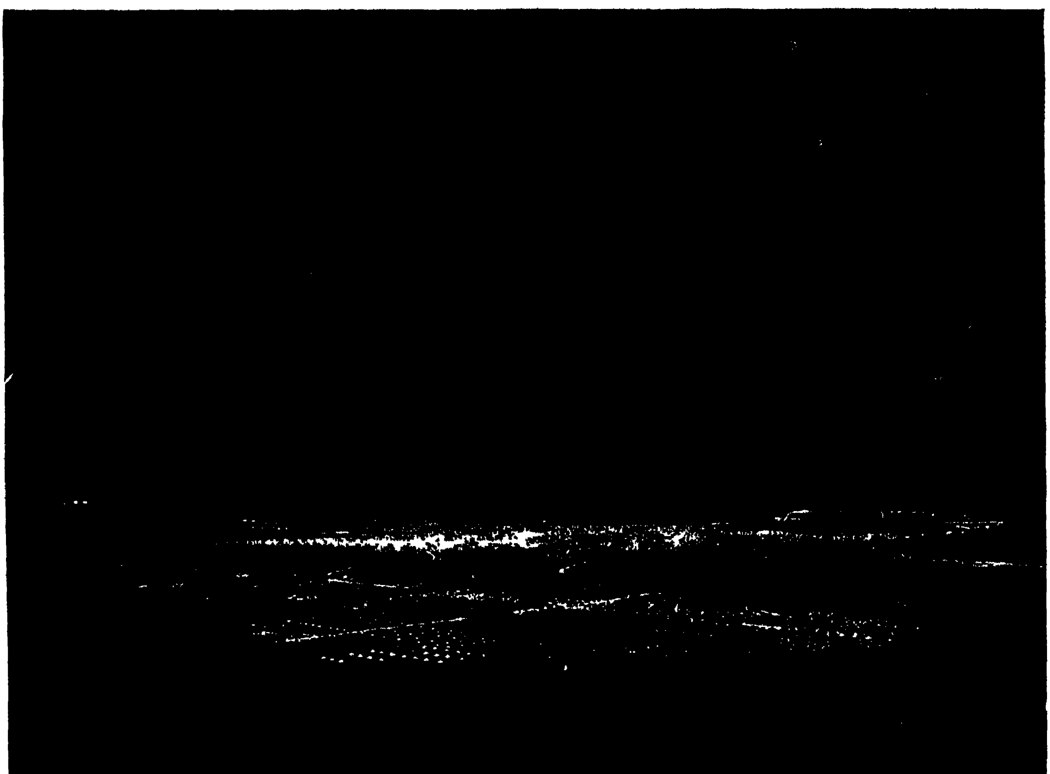
So much progress has been made in cheapening and improving the illuminating powers of coal gas and electricity that the oil lamp may seem to have no future before it Yet there is at least one very important lighting function in modern civilization for which oil remains as yet unrivaled. For most of our great lighthouses burn kerosene. An incandescent burner, using kerosene oil vapor with an incandescent mantle, has been found more effectual than anything else. The yellowish light so produced penetrates further through mist and fog than the glare of an electric arc lamp; and it is superior for lighthouse purposes to other new forms of illumination by reason of the ease and simplicity of its production.

Prior to 1895, acetylene gas was hardly known outside the chemical laboratories. In its liquid form it was fatally easy to explode, and its destructive power was equal to that of nitro-glycerine. But in 1897, Georges Claude, the inventor of the neon light, found that acetylene gas could be absorbed by a chemical obtained from

wood, and stored in cylinders under considerable pressure. A few years later another Frenchman, Foucher, found that by mixing the chemical from wood with charcoal or some other porous substance, compressed acetylene could be safely made for popular use. Produced from calcium carbide, at comparatively little expense, the new gas was first employed, in a general way, as a strong and windproof light for bicycles and automobiles. But it is peculiarly suitable for various kinds of automatic lighting.

A few years ago an acetylene lighthouse that works automatically was built in an English port, and now some railroads in the United States are using acetylene to light the signals along their lines. At the foot of each signal is a chamber containing the compressed gas that automatically lights two burners for several weeks without recharging. The cost is so small that the lamps are frequently allowed to burn continuously. Some railway authorities in Germany, however, have come to the conclusion that a flashing light, such as is used on many lighthouses, is more visible and noticeable than the ordinary steady colored flame used in railroad signals. So they have devised a kind of acetylene lamp, from which the gas passes from the receiver to the burner in slight quantity, at quickly repeated intervals. The flashing signal flame is said to be not only cheaper in working, but more effective in practice than the ordinary railroad signal lamp.

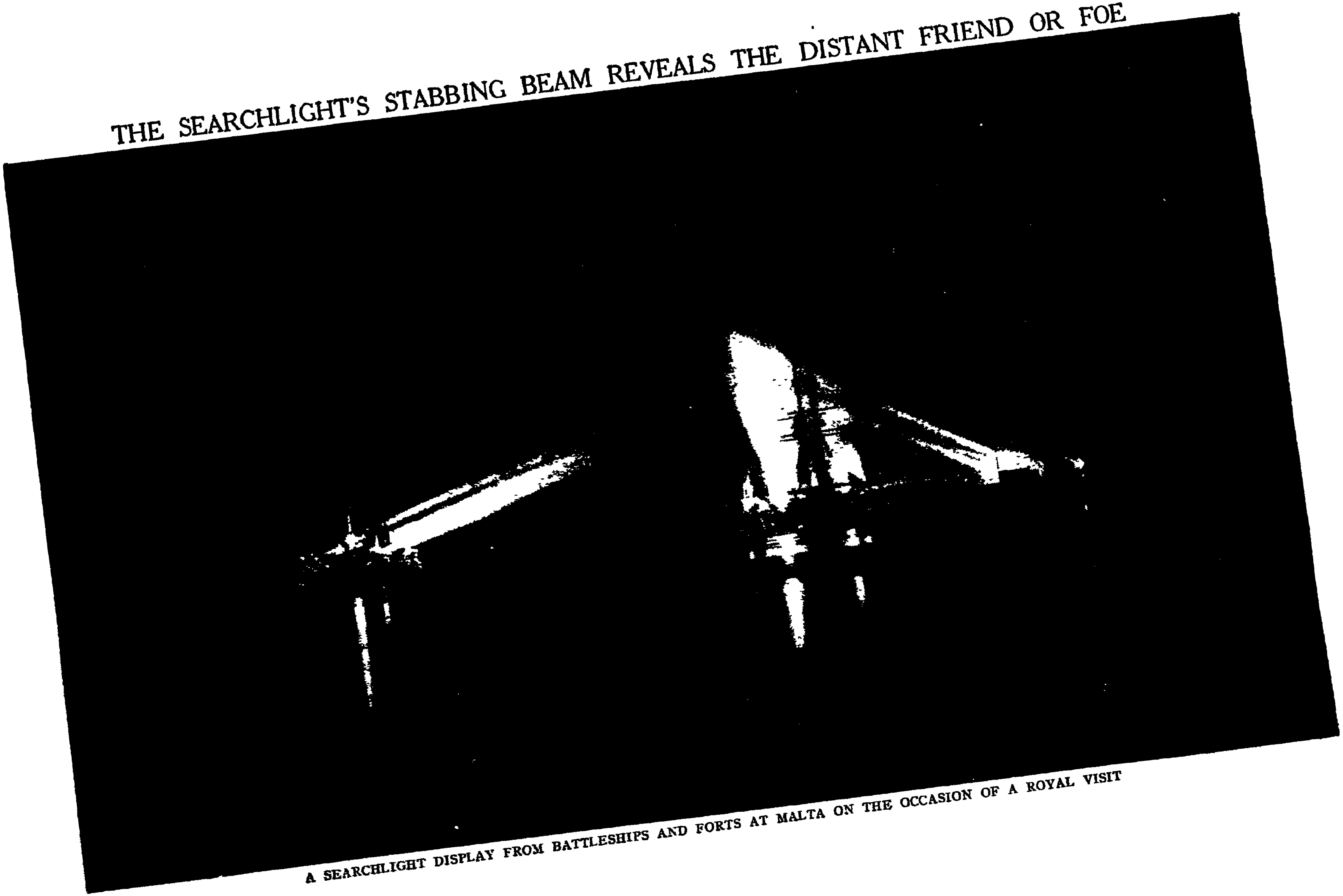
By reason of the saving of the cost in pipe-laying, compressed acetylene gas seems to be an economical source for municipal lighting purposes. The acetylene light can be produced economically, independently of the industrial conditions of a neighborhood. It is much used in the private lighting plants of country houses.



THE CITY'S DISTANT GLOW

The city lights of Pasadena and Los Angeles and of beach towns 8 to 30 miles away, as seen from Mount Wilson Observatory.

THE SEARCHLIGHT'S STABBING BEAM REVEALS THE DISTANT FRIEND OR FOE



A SEARCHLIGHT DISPLAY FROM BATTLESHIPS AND FORTS AT MALTA ON THE OCCASION OF A ROYAL VISIT

THE PATHWAY OF OUR FOOD

The Need for Establishing Rules for the Regular, Unconscious Working of the Body's Mechanism

THE PROTECTIVE POWER OF DENTISTRY

FAR more important than most of our discussions about the kinds of food is the proper care of the alimentary canal, which has to deal with the food. If the machinery be in good order it will get value out of almost anything; if it be out of order nothing may be of any value at all. At and in the very mouth of the alimentary canal are the teeth, and a primary condition of health is either to have sound teeth or, at the very least, to have no unsound ones. For the first of these alternatives no prescription can surely avail. Heredity has too much to say in the matter. If we happen to belong to certain of the backward races, we shall almost certainly have thirty-two perfect and unassailable teeth. If our heredity is more fortunate in other respects, it will probably be less fortunate in that. We therefore cannot promise ourselves that the best care in the world will preserve our teeth, or be warned that the utmost neglect will hurt them — "it all depends". We all differ in our chemistry as in our faces. Hence the kinds and number of bacteria that can inhabit our mouths differ also, according to the particular character of the secretions which our mouths produce. Upon this, essentially, the fate of our teeth depends. If they decay, it is because certain microbes produce acids which slowly dissolve the salts contained in the enamel covering of the teeth; if they survive, it is either becausé the mouth will not allow such microbes to exist in it, or because it produces such alkaline secretions as neutralize the bacterial acids.

There are certain factors at work here which we can only very imperfectly control. But what we can do is eminently worth while doing.

It may be doubted whether the students of the chemistry and bacteriology of the mouth have yet found out the exact agent which destroys our teeth. It is, no doubt, something derived, or often derived, from sugar, though, even so, we know now that one may take abundant sugar and do one's teeth no harm. Probably the finest teeth in the world are those of, say, West Indian negroes, who suck the sugar-cane all day long and every day. Nor are we clear as to what the sugar yields when microbes do attack it — as they doubtless do not in such cases.

One thing is certain, however. It is that no one should permit himself to go about with even a single decayed and uncared-for tooth. The decayed tooth is, as such, a source of danger. We may argue as we will whether it should be removed, or repaired, and whether, if removed, it should be replaced. The one certainty is that it should not be allowed to remain in a state of decay. Scarcely more than a generation ago dental work was looked upon as æsthetic but not much more. The decayed tooth was not seen to matter — at any rate, if it was not seen it did not matter. Now, however, dentistry is recognized as representing a very important phase of preventive medicine. The feeling of physicians at the present time is that the mouth is one of the most vulnerable avenues of the body for invasion by disease.

Chronic affections directly traced to infection of carious teeth

Only those who have been following very recent medical literature will appreciate that there is a series of the most painful disabling and chronic affections, severe diseases of the nerves and joints, the so-called neuritises and arthritises, the origin of which is now traced directly to infectious processes due to carious teeth. The mouth instead of becoming freer from disease with recent developments of sanitary science has become the focus of more and more bacterial processes.

The teeth are considered so important for health that not a few rejections of drafted men during the Great War were made because of conditions within the oral cavity. If the published record of the War Department should do no more than call public attention to this recent development of medical knowledge with regard to the dangers of mouth infections, it will have accomplished much for the improvement of the general health of our generation

Dental caries is due to microbes, whose chemical products define the odor of the mouth in which they are permitted to thrive. These products tend to be swallowed, of course, and they are to be looked upon as poisons. If a child or an adult has bad teeth, mastication will be imperfect; the food will go, inadequately prepared, into a stomach which is also being poisoned by foul products from the mouth. This is the root-cause of indigestion in hosts on hosts of cases, and their treatment and cure are the simplest things in the world once we grasp their nature, as we usually fail to do. No adult and no child should be permitted to suffer from these risks.

It matters far more than merely in that a clean mouth, containing no foul teeth, protects us from a constant source of blood-poisoning. At any rate, it is enough to know that many cases of ordinary anæmia, with indigestion and all the attendant symptoms, may be cured by the dentist's steel when even the physician's iron fails altogether.

But there is much more to say. The commonest cause of neuralgia and headache, by far and away, is dental caries, especially in the upper jaw. The doctor, if he still exists, whom you consult for neuralgia, and who prescribes phenacetin or such drugs, while neglecting to examine or inquire after the teeth, is a man to be shunned as irresponsible or incompetent. No one must touch drugs for headache or neuralgia until the dentist has discharged him — and not then.

The openings offered to infection by decayed teeth

But the blood-poisoning, with its anæmia and indigestion, and the neuralgia, are still the least of this question. The most important fact about a decaying tooth is that it is an invitation to infection. Valuable and alive though the tooth is, it is not a vital organ. If the microbes that enter it merely stayed there, we should only have the tooth, at worst, to regret. We know, of course, that they sometimes go further, and then one has a gumboil. These are very "trying", but not very serious. Occasionally the bone of the jaw may itself be attacked, or an abscess may form within the cavity of the upper jaw. Care of the teeth averts these more or less obvious risks, but modern pathology raises entirely new considerations.

The healthy body is well protected against microbes. No microbe can pierce unaided the outer layer of the skin. Probably the same is true of the lining of the mouth, and the surface of the healthy tongue and tonsils. The hydrochloric acid produced by the healthy stomach is a splendid and invaluable antiseptic. Risk begins with a *breach or degeneration of surface*. This may be minute, even microscopic, for so are microbes, but it makes all the difference. Thus in our study of the routes of infection, above all of tuberculous infection, our search begins to be narrowed down. We most of us swallow millions of tubercle bacilli in our milk, but they perish in the hydrochloric acid of the stomach. Yet certainly the bacilli in milk do gain entry to our bodies, and especially to our children's.

Where signs may be seen of the entry of infection

Over and over again the infection shows itself in the neck. Why should the glands of the neck suffer so much, and whence does the infection reach them? Why, also, should the apex of the lung, its highest point, be so commonly the first to be infected in consumption? The answer is that we do not properly guard the portals of the body. The healthy mouth, nose and throat can take care of themselves, and of us. But the decayed tooth will convey the microbes of tubercle readily, by means of the lymphatic vessels, to the lymphatic glands in the neck, and to the lungs themselves. The diseased throat, crowded with adenoids, and with swollen, futile tonsils, is a further invitation.

If you want to keep dangerous people out of your house, you shut the door. The door of one's bodily house has to be opened, to eat if not to speak, and enemies are constantly admitted in this fashion. But what could be a more elementary precaution than to see that no morbid openings lead from mouth and throat into the body itself?

It follows that the value of good dentistry can scarcely be overrated. The contrast between good and bad dentistry is at least as marked as in any other profession, and the best dentistry of today is extraordinarily good. One would require to be very poor indeed in order to be unable to afford the fees of a first-class dentist, for the possession of good teeth, or, at least, the non-possession of decaying teeth, is a *sine quâ non* of health. The cost of the good dentist's work has to be reckoned as against the amount of life which it provides for us. Further, the good work endures, as bad work does not.

The deterioration of teeth partly a consequence of unnatural diet

But the savage and the dog need no dentistry; and when we ask why we should, it has to be admitted that our teeth are not what they should be. There is something to be said for the view that our tendency to dental caries is inherited. Time was when the possession of good teeth must have had some value in the struggle for existence. Those who had bad teeth would tend to disappear. But dentistry and modern cooking have reduced the importance of naturally good teeth so much that many people with naturally non-resistant teeth now survive and have children like themselves. At any rate, there is no doubt that cooking, and the selection of food, in modern days have interfered with the need for thorough and natural mastication, and that the teeth are thus deprived, in early years especially, of the exercise and ample blood-supply which they require.

There is no doubt, then, that, in the discussion of dental hygiene diet is the first thing to discuss; and we should not start out with toothbrush and dentifrice until we have duly considered first questions first. The toothbrush follows. But there are right and wrong ways of using a toothbrush. The mere motion of the brush from side to side chiefly cleanses the flat surface of the teeth, which is least in need of attention The proper motion is up and down, so as to clear, as far as may be, the spaces between the teeth. Fortunate are those people in whom these spaces are considerable, so that nothing can long lodge in them One should use the brush almost after the fashion in which a razor is stropped, that is, with a rotation, so as really to do the essential thing, which is to *clear crevices*.

The proper uses of small toothbrushes and simple dentifrices

The brush should be small, it should not be very soft, for such a brush may simply squeeze material into crevices, nor very hard, except for very fine, hard teeth. The injudicious use of too hard toothbrushes, with side to side motion, and with a gritty dentifrice, is apt to wear away the enamel, especially on the exposed aspect of the eye-teeth; and that is the very last end for which one uses a toothbrush.

The requirements of a dentifrice are simple enough, and very definite. There are many pleasant antiseptic fluids on the market, no doubt desirable as mouth-

washes, but they do not have the first necessary qualification of a dentifrice, which is that it should be solid. It must be a powder with a mechanical action, but it must be entirely incapable of scratching the teeth; it will be antiseptic, of course; and it will be alkaline, thus supplementing the action of the alkaline saliva in neutralizing the acids of microbic origin which cause dental caries. A half-and-half mixture of carbolic tooth-powder and powdered chalk serves very well. This is quite cheap if one has the sense to do the mixing oneself, and to buy the ingredients in large quantities. The addition of a little bicarbonate of soda (baking-soda) to the water in the tumbler when one brushes the teeth at night is also highly to be recommended. This antagonizes the destruction of the teeth along the edges of the gums.

Impaired physical condition of school children largely due to unsound teeth

Lastly as regards children, it has been found that the serious septic complications of scarlet fever are much more common and severe in cases where the teeth are bad; that the children with the worst teeth are unhealthy in appearance, and below the average in weight, and nearly always below the average as regards their school-work in proportion to their age.

An English authority, reporting to the British Dental Association, calls attention to the fact that: "The mental and physical development of the children attending the public elementary schools is much hindered by the wholesale neglect from which their teeth are suffering; their susceptibility to diseased conditions is much higher than it would be if their mouths were kept healthy; and, moreover, should they be unfortunate enough to contract scarlet fever, the probability of their suffering from one or other of the serious complications that frequently follow this disease would be considerably increased. In short, the prospect of a child deriving the full benefit of the instruction provided in an elementary school is much impaired by the prevailing condition of the teeth."

In America great efforts have been made to correct this. A system of physical examination of school children is now in operation in more than 400 of the cities in the United States. Nurses have been appointed to assist doctors in their examinations and direct the children to free hospitals and clinics. In the great Forsyth Dental Institution at Boston 200,000 treatments can be given annually

Constipation the commonest malady due to modern abnormal conditions

We are responsible for the care of our teeth, and then for the care of the bowel. Numerous and complicated processes intervene, but they are, fortunately, beyond our control, and in no need of our supervision. We do our duty to ourselves, or those for whom we are responsible, if we attend duly to the diet, to mastication, to the teeth themselves, and to the bowel.

The abnormal conditions of our lives are responsible for the attention which so many people require to pay to what should require none. The careful selection of our diet, its careful preparation (all directed towards reducing the quantity of "ballast"), together with our too-often sedentary mode of life — which means that the muscles both of the abdominal wall and of the abdominal organs tend to lose their tone — these combine with the hurry of our lives, making us feel that we must get on to our work the instant after breakfast, so that, in the upshot, constipation is established as by far the commonest malady of the civilized world. Notable testimony to this fact, familiar to all general practitioners, is furnished by the analysis of patent medicines They are consumed to an amazing extent, and by far the greater part of all of them simply consists of aperient substances.

The mischief that follows from using aloes as a regular aperient

The standard stimulant of the lower bowel which is aloes, is *the* constituent of the most popular pills and syrups, and so forth. These drugs must not be condemned outright; they are, of course, absurdly expensive, but that doubtless

helps, in an unsophisticated world, by providing or fortifying the element of faith or auto-suggestion, which tells powerfully upon the action of the bowel. But they do effectively relieve the constipation of hosts of people; and if their use were strictly occasional, there would be little need for criticism. On the other hand, the action of aloes is too much confined to the lower bowel, and it largely acts by causing congestion of the veins, which is often apt, in predisposed persons, to lead to the development or aggravation of "piles", or hæmorrhoids. No one, therefore, should take aloes in any form as a *regular* aperient. For that purpose, if, indeed, any medicine is to be employed — and no medicine is necessary for the purpose in those who properly regulate their diet — we require a blend of drugs, so as to act gently but equably on the upper as well as the lower part of the bowel.

The importance of constipation, we need hardly remind ourselves, is not mechanical, but chemical. Microbes appear in the bowel of the infant about the tenth or eleventh day, we are told, and thereafter they are never absent. If the secretion of the kidneys be carefully examined, we can readily find in it, in cases of constipation, toxic substances which we can prove to have been formed in the bowel. The proof is absolute, then, that these toxic substances have been absorbed from the bowel, have circulated in the general blood-stream — going, therefore, to the brain, as everywhere else — and have finally been excreted. The theory of auto-intoxication by constipation is thus established.

Dieting needed with advancing life to avoid self-poisoning

This is the key to many of the facts of advancing life in a host of cases. Sir Thomas Clouston, in his book on "The Hygiene of Mind", says on this point: "Vague feelings of organic bodily discomfort interfere with the full enjoyment of life, and mean that the processes of nutrition, and the working of the great internal organs connected with digestion, are not done as well as before, and no longer give conscious satisfaction. This feeling is often connected with a newly developed constipation of the bowels, and with the diminished keenness of the appetite for food." The author goes on to say that these symptoms are due to an auto-intoxication which demands a considerable modification of the diet at this time of life. This modification should take the form of reduction, and it is particularly necessary to control the constipation to which he refers.

Doctors commonly lay down the rule of "once a day" for an adult. Let no one suppose that this would suffice for an infant, or that the figure is in any sense absolute. There are hosts of exceptions, in both directions, to it which are consonant with perfect health. Many people double and many halve this frequency. The diet of the individual is a most important factor. Whatever the habit be, within reasonable limits — and once in two days is probably the extreme in that direction — at any rate there should be a habit, and it should be adhered to rigorously. This means a healthy education of the bowel as far as its subconscious regulation by the nervous system is concerned.

The great importance of establishing regular bodily habits

We have already hinted at the importance of faith in the control of the bowel, and, indeed, there is no part of the body, nor any function, more closely susceptible to nervous influences. The influence of fear is familiar to most people. Now, in these circumstances it is well to establish a sound habit; and while this is easily and quickly done, it is still more easily maintained. In extreme cases of nervous constipation, in persons suffering from neurasthenia or nerve-weakness, actual hypnotic suggestion may often be successfully employed.

But any reader may train himself in this fashion, with the practical certainty of success. The hour, of course, should be after breakfast, when the various movements associated with getting up have begun to wake the bowel from without, and the breakfast has stimulated it from within.

The need for making the use of aperient drugs unnecessary

The smoker, also, has trained himself, as a rule, to be helped by, if not, indeed, to require, his after-breakfast cigar or pipe for this purpose. The hour must be rigidly adhered to, inclination or no inclination. Enough time must be allowed for the purpose. This is often overlooked, especially as the business man usually has little time to spare at this hour of the day. The nervous apparatus may decline to be hurried, and its action may be absolutely arrested by the consciousness of hurry. So are we made. But if a fixed hour is adopted and adhered to, and if a sufficient time is always allowed, the necessary nervous habit can be formed by anyone.

As for drugs, we have already admitted that it is much better to use them than to be constipated, but it is better still not to require to use them at all Their use costs money; the dose requires to be increased, just as in the case of hypnotics; and very few of those who use them are subtle and careful enough in their choice to avoid doing harm.

The choice of diet with a view to the natural disposal of food

We have repeatedly insisted here that it is absurd and impossible to judge a diet merely by its nutritive constituents, and to assume that one food is three times as valuable as another because it contains three times as much protein, or what not. Such judgments are absurd, not merely because we do not yet know enough about the elements of nutrition, but also because our diet has at least two important functions to discharge besides feeding us. As we have already seen, the ideal diet should also be, or include, an effective dentifrice, as in the case of the lower animals; and our dietetic theories must either be "squared" with the dental need or else we must take very special and artificial precautions regarding our teeth. Secondly, the ideal diet must be so contrived as to provide for the health of the bowel, and therefore we now must make a few notes upon diet from what is thus a third point of view.

The virtues of oatmeal, graham bread, crusts and fruit

For the relief and avoidance of constipation, oatmeal, oat and graham bread, with its bran, are to be commended Fresh fruits especially are valuable, partly on account of the aperient salts they contain Everyone should eat some fruit every day. It is valuable for the teeth, for the bowel and for the blood, and it is the ideal fashion in which to supply one's self with water. Fresh fruit is the best, like fresh vegetables and fresh everything else, but, for the bowel especially, stewed figs and prunes are very useful. Recent developments in the commerce of diet have been very favorable to national health. The introduction of the grapefruit, the melon and various berries, the cheapening of the banana, the enormous increase of the trade in canned fruit, and the great extension of the "season" of the orange have all helped.

The value of simple fluids between meal and exercise

Often constipation can be much relieved by increasing the consumption of fluid, especially between meals. Milk is somewhat constipative, and buttermilk may sometimes be substituted. It is highly nutritive, and may have some special virtues. Nothing can be less sensible than the too common custom of taking aperient medicines every day, while consuming large quantities of, say, improperly made tea, containing an abundance of that highly astringent (*i.e*, literally "binding") substance tannic acid. The combined anæmia and constipation which afflict so many domestic servants are largely due to their unwise diet, their undue indulgence in badly made tea and their lack of exercise Constipation is markedly opposed by exercise, and especially by those forms of exercise which involve the vigorous use of the abdominal muscles. The reader who follows, in reason, the advice here given can scarcely fail to insure for himself a healthy acting and active bowel, which will safely absorb his food into his blood, and no poisons with it.

THE RISE OF COÖPERATION

The Reconciliation of Individual Enterprise with Cooperative Effort in the Production of Wealth

SOCIETY AS A COOPERATIVE FRAMEWORK

COMPETITION is as instinctive in man as self-preservation, of which, indeed, it may be regarded as a phase. It is an instinct which throughout the animated world leads individuals to wage their chief contest with their own kind in the struggle for existence. In some sort it will undoubtedly survive in human society; and the working out of the form or forms of its continuance creates some intensely interesting problems.

In the field of economics competition has been defined as the unrestricted exercise of the self-interest of the individual, but in this strict sense competition can scarcely be said to exist at all, save where established by State law, or when it is the exercise of a supreme individual gift, as in the case of a highly talented artist.

Under a system of unrestricted and unregulated competition the life of man would be a fierce struggle between individuals each desirous of securing the largest possible share of the product of human activity; and the mental picture that is conjured up by the words is an exceedingly unpleasant one. In all ages and in all countries competition has been regulated more or less by custom largely springing from human affection. Custom in particular plays a part in the purchase of labor, in which regard it has always been a powerful safeguard for the weak.

The customs and usages which arise in all countries had their basis in rude justice. An excellent illustration of the manner in which custom conquers competition is the metayer system of land tenure which exists in Italy and elsewhere, by virtue of which the land proprietor leases a farm to a family, usually supplying the necessary agricultural stock, and takes as rent half of the produce of the farm, whatever that produce may amount to. Where this custom is established, no one dreams of either offering or accepting any different terms, no matter how the price of produce may vary, and no matter whether the land yields much or little. That means the absolute elimination of competition by custom.

A very striking instance of the partial elimination of competition is to be found in the honorable customs of some of the professions. The charges of doctors, for example, are largely so regulated. It is true that many physicians have a somewhat flexible scale of charges; that is, their fees resemble a tax system in which the levies on the rich are heavier than those on the poor. Many skilled surgeons charge a rich man more for a major operation than they would a poor man. But, except as a physician's fees are tempered somewhat to accord with the financial ability of the patient — a practice for which much may be said — he sticks closely to a uniform scale of charges, with a stated amount for an office consultation, another for a visit at the patient's home, etc. Architects, too, have a fairly uniform scale of charges, the fee being usually a stated percentage of the cost of the proposed building. With lawyers, a different custom obtains. Usually, as a lawyer's reputation increases he raises his fees, until we hear of fees of $25,000, $50,000 and even $100,000 in a single case. In the medical profession, however, as in many other walks of life, competition is, for practical

purposes, eliminated so far as it affects price, although it exists, of course, with respect to the amount of work to be obtained. The modifications of pure competition, indeed, are so many that it is plain that the higher qualities of men are able, under many conditions, to triumph over self-interest. The Economic Man, as a "pure type", rarely or never exists.

Will the desire to excel be weakened if competition is modified?

Nevertheless, the circumstances of a complex society which, as we have before remarked, often hide the real character of operations even from those who engage in them, make it difficult for individuals to discern the play of economic forces, and to understand when competition has proceeded to lengths which are socially undesirable. The customs of a simple community, in which everyone is acquainted with everyone else, and feels honorably bound to deal fairly with everyone else, may be altogether erased in a complex civilization in which next-door neighbors do not know each other's names, and in which the ties of human affection are difficult to maintain.

Educators have sometimes complained that the spirit of competition is instilled into children at school, and that the whole tendency of our method of training is to imbue the young with the idea of "getting on", that being an exercise in the art of climbing on the shoulders of other people. Others, again, contend that if the spirit of emulation were not instilled into the child, progress would cease, since no one would desire to excel. It does not follow, however, that the desire to excel may not exist together with a recognition of the folly of unrestricted competition.

The advantages of free competition to the consumer

It is conceivable that a boy could without very much difficulty be trained to honestly believe that civilization might be run on exactly the same principles which obtain in the case of a football eleven or of a national army.

Turning to competitive industry, we see it carried on by a very considerable number of business men, each intent upon supplying as large a part of the available market as possible What is the available market? As far as the home market is concerned, it consists of the power possessed by the nation at large to purchase the particular commodity. At any given moment that power is definitely limited, not by desire, but by necessity. The competitors seek to secure orders in this limited market, which, taken as a whole, they have no means of measuring. There is both good and evil in the position which obtains. Each business man, in his desire to secure a hold on the market, does his best to attract customers by making his goods attractive and sometimes by cutting prices. In pursuance of these objects, he seeks to apply better processes and inventions, and the desire to excel his competitors is strong in him. These things make for the benefit of the consumer of the commodity in question, who sees a number of men fighting together for the privilege of serving him. In this struggle for trade, fine qualities may be evolved, and, other things being equal, those best fitted to supply the market will triumph. By a process of natural selection the unfit are eliminated, and the trade comes to be carried on by a group of men better qualified for the task.

Disadvantages that accompany the process of unlimited competition

On the other hand, great evils accompany the process. If there are, say, one hundred entrepreneurs in an industry competing with one another, the chief difficulty of any one of them is not to make goods but to sell the goods that he has made in competition with his ninety-nine fellows. The crux of the business is not the making of goods, but the selling of goods. The chief concern of the manufacturer is not with the technical side of his business, but with the commercial side. Under such circumstances, striving becomes more a matter of striving for the market than of striving to produce better goods.

Indeed, the striving to produce better goods is only too likely to be regarded as a wholly subordinate matter. Moreover, if there is a considerable number of business men engaged in a limited industry, they cannot all be in the possession of large capital; and if a large capital is required to conduct the business economically, then the most economic working of the business must inevitably fail.

Again, the maintenance of a hundred separate businesses calls for expenditures which, regarding the industry as a whole, are obviously wasteful. Each of the hundred firms must necessarily have separate plants, separate warehouses, separate offices, separate managers, separate sets of clerks, separate staffs of traveling salesmen, separate accounts, separate advertisements, etc. If the industry has a hundred separate concerns engaged in it, there must be borne upon it as a whole the cost of maintaining thousands, or tens of thousands, of employees who are unnecessary from the point of view of the industry considered as a whole. Bearing such unnecessary costs must largely counterbalance, or more than counterbalance, any cutting of prices which is effected by the competitive process; or, to put it another way, none of the firms can afford to cut their prices below a point which will enable them to maintain the necessary appurtenances of an individual business.

The puzzle of how to find out what it is best to buy

Many other considerations arise which make the competitive system anything but advantageous to the consumer. Even the common necessaries of life — wheat, meat, coal, etc. — may be subjected to manipulations of price which are abuses of the competitive system. With regard to other commodities, such articles as clothes, shoes, hats, pianos, automobiles, etc., the ordinary man is puzzled to know where and what to buy. So far from competition helping him, it confuses him by presenting to his mind such a mass of advertising matter and contradictory statements that it is next to impossible for him to arrive at a sound judgment.

Directions in which competition has been eliminated already

Indeed, the market in any particular commodity often presents itself to the buyer in very much the same way as the business signs in a crowded thoroughfare. The object of such a sign is to attract attention. When, however, in a long street of tall buildings each tenant of each floor of each building displays a sign which endeavors to outbid all the others in effectiveness, the result is so confusing that the signs defeat their primary object, and bewilder instead of aiding the stranger. This is equally true of much modern advertising.

These and other considerations which might be named are undoubtedly becoming increasingly recognized by practical business men. In so far as competition is harmful or uneconomic it must in the long run come to be eliminated, which is not by any means the same thing as saying that human competition must end. If we consider society, with its professions, trades and industries as it now exists, we cannot but be struck with the degree of elimination of competition which has already taken place. As to those industries which involve the use of pipes or conduits, or lines, or wires, or tracks, it is so easy to see that competition is an absurdity that for all practical purposes civilization by common consent has abolished competition in them in all countries.

The necessary return of monopoly into some modern business

Steam railways, canals, street-car lines, telegraphs, telephones, sewers, water supply, gas supply and electricity supply are everywhere carried on on a monopolistic or quasi-monopolistic basis. Sometimes the industry is privately owned; sometimes it is nationally owned; sometimes, again, it is controlled by a municipality or other local authority; in every case it is a monopoly or it is verging toward monopoly. The exceptions are so few as to be negligible, and where they obtain they point to a blindness which can only be termed extraordinary.

What would be said if, in a single street, two or more separate surface sewers were constructed to carry away the rain-water which could be easily dealt with by one? What should we think of the spectacle of two or more competitive street railway systems lining a street with their unnecessary rails in order to carry on an unnecessary competition? Surely even children would smile if in the same thoroughfare two separate water pipes were laid, and some houses took their supply from one of the systems while others preferred to be served by the second.

Consideration will show that it is the use of the tangible and suggestive pipe, or line, or wire, or rail which demonstrates to the mind that competition in the business which employs it is wasteful. We see clearly, without the need for even brief argument, that the rail, the pipe, the line, the wire, ought to be used to the limit of its economic capacity, and that it is absurd to create a second or a third or a fourth, when the one would do. That is why everywhere, or almost everywhere, competition has been eliminated in the industries or enterprises referred to.

The obvious waste of unnecessary duplication in the United States

This end has not been reached, however, without a good deal of blundering. So far as the lesson has been taught, it is as a result of unhappy experience. The cities in the United States — and in other countries, too — have sometimes tried to force competition into these naturally monopolistic fields. Some American cities have actually seen the absurd spectacle, mentioned above, of two different sets of tracks on the same street utilized by two different competing street railway systems. Other cities have permitted their streets to be torn up twice in order that the mains of competing gas or water companies might be laid. The waste of such unnecessary duplication is so obvious, the economies of consolidation are so clear, that competition in such undertakings can never be permanently maintained. Some promoter is bound to seize the opportunity to capitalize the obvious advantages of combination and thereby to reap personal profits for himself. In some instances, even, a franchise has been secured for a competing street railway company or a gas company merely as a threat, as an instrument of extortion, by which the company whose plant is already in operation could be blackmailed into paying a high price to ward off the threatened competition. Burdens of this kind fall inevitably upon the public in the long run, and in general quite properly, for it is the public, through its absurd and wasteful encouragement of competitive undertakings in fields that are inevitably monopolistic, that should be held responsible for the waste.

The coöperative framework that includes water supply, sewerage and lighting

In every civilized country, society has formed a coöperative framework without which life would be exceedingly inconvenient and uncomfortable. The common road is the simplest example of this framework, and in a civilized community it is maintained out of public funds, fed by the common contributions. We do not make individual and competitive tracks for ourselves; we agree that the function of providing and maintaining suitable roads should be discharged by public authorities, who perform their work with more or less efficiency according to the degree of public spirit which obtains in any particular locality. We are apt to regard our roads as "free" because tolls have been abolished. As a matter of fact, we pay our road tolls when we pay our taxes or our automobile license fees, and the bill we then discharge is in ultimate analysis as much a matter of "business" as the act we perform when we buy a suit of clothes or a pound of butter.

The drainage and water supply have also come to be in very great part things of common use which are maintained as part of the social framework. When these things were left to individual and chance effort they were done so badly that great loss of life and much preventable suffering was caused. The terrible plagues of ancient days were simply the result of the

lack of an essential part of a coöperatively sustained framework of society. It is next to impossible for each family in a thickly populated community to dispose properly of sewage; and it is important to note that there is tacit agreement that the thing cannot be done by competitive enterprise. We do not argue about this; the argument is never raised. It is never suggested that the management and control of sewers should be left to private hands.

That is a very significant fact, and it reminds us forcibly how commonplace important things really become when the best way of working them has once been sensibly arrived at.

And thus it is again with lighting. Time was, of course, when the lighting of roads and streets was left to the hanging out of more or less efficient family lanterns, and when linkmen lighted to their destinations those who could afford to employ them. Nowadays, civilization, from New York to Melbourne, from Montreal to Buenos Aires, establishes and maintains public lighting of a very efficient character. The public lighting system is as much a matter of course as the public sewer, and it is so universally recognized that in these respects coöperation is the only sensible course that no argument to the contrary is ever heard of in any country.

Canal ownership and the postal system as example of social coöperation

In some countries the canals have been placed on the footing of common roads, while in others tolls are charged. In others, again, private canal ownership may be permitted, as in England and the United States. In every case, however, the necessity to eliminate competition is recognized, and we do not witness the absurdity of rival canals running side by side. As to railways, we saw in a former chapter that the general rule in civilization is to bring these under public ownership. Even where private ownership prevails, however, competition is rare and impossible to maintain in the nature of the case. The same is true of street railways, telegraphs and telephones.

The history of the United States affords several instances of the wasteful and virtually useless building of parallel lines of railroads. In some cases, the second line was built as a "threat", as something that might be sold at a high price to the older road. But public sentiment, and often public appropriations, were enlisted on behalf of the new line, on the ground that "increased railway competition would reduce rates". Such hopes are and always have been chimerical. Railway competition has sometimes led to sporadic rate wars that have done the public and shippers more harm than good; it has never reduced the general level of railway rates.

Recent state legislation indicates that the United States has passed into a new phase of its history so far as its transportation systems are concerned. Formerly it was believed that it was to the public interest to build a canal or railroad no matter where its terminals, no matter what its probable traffic, no matter what its effects on the values of property already existing. Formerly the public treasury was tapped from time to time for assistance to private companies that were constructing railroads. Nowadays, although the money is still wasted from time to time in futile and useless waterways, planned without reference to the real economic needs of the country as a whole, a railway company is required to secure in most states a certificate of public necessity and utility before it can begin construction. The burden of proving that the railroad is necessary, that it would be a utility, is put upon its promoters.

We do not mean that the nation should be niggardly in its attitude toward great and important works of internal improvements; we merely mean that the nation should not permit enormous amounts of capital to be wasted in the future as they have been in the past in the mere duplication of existing public works, or in the constructing of public works which, under scientific analysis, cannot be shown to have a reasonable hope of achieving economic success.

What would happen if the mails were worked by competition

As to the postal system, it is the universal rule to make it part of a social framework while charging users according to their degree of use Nowhere in the world is there any competition in the postal business, and it is freely recognized that it would be very undesirable for such a trade to be carried on upon a competitive basis.

If the post offices of the United States or of Canada were abolished tomorrow, and the work left to the ordinary play of competition, there would at once spring up letter-carrying companies and firms in all parts of the country, each of them with a separate management, staff, accounts, etc. In big centers of population, such as New York or Chicago, Montreal or Toronto, there would undoubtedly arise a number of local competitive letter-delivering undertakings, each of which would necessarily have to keep accounts with the others. Under such a system, left to free competition, a letter, to pass from the United States to Canada, or *vice versa*, might have to go through the hands of a host of different agents, and the unnecessary work caused would be obviously very great. As a result, the cost would be prohibitive to the poor, and a heavy tax upon even the well-to-do.

The postal business is a striking example of how to accept accomplished facts and cease to examine them, or even to think about them. We do not realize that it is only because the postal service has been made a public service in each country that we can with so much assurance deposit a paper envelope in an obscure post office in the backwoods, and rely upon it that, in exchange for a couple of cents, the tiny missive will be safely delivered within a short space of time in some equally obscure town in Canada or Latin America. We have here a most striking illustration of what can be done by the exercise of the coöperative principle, but it is a lesson which escapes attention, because when an industrial miracle is performed every day, and every hour of the day, it ceases to be one to us.

How the milk supply might be under public management with advantage

It is not only in those industries in which some visible material connection suggests the advisability of cooperation that cooperation is being secured. There is no real distinction between a business that is carried on by pipes and a business that is carried on without visible material tracks or connections. Water is a fluid, and milk is a fluid; and a moment's thought will show that it is no more necessary to have twenty suppliers of milk in a small town than it is necessary to have twenty suppliers of water. It is not, of course, possible to transmit the milk by means of a pipe, because its purity could not be preserved. If, however, the most economical result is to be obtained, it is clear that the milk supply of a town ought to be under a single control, in order that the cheapest and best results may be obtained, and all unnecessary expenditure of labor avoided, to say nothing of the great necessity of protecting people from the danger of impurity by contagion from a fluid which, because of its magnificent nourishing properties, is a terribly efficient conveyor of organic disease.

If there are two, three or more sets of milk wagons up and down a single street, it is precisely the same kind of economic arrangement as though there were two, three or more lines of water-pipes laid in the street. Obviously, the most economical arrangement would be for one delivery wagon to proceed to the street with a supply of milk sufficient for every family in it, and for the milkman to economize his time by passing from one door to the next consecutively.

In many industries, the economies of consolidation have been so great that they have led to the organization of combinations and trusts. These have created new public problems which will be discussed in another chapter. Combination is in the public interest if a proper share in the economies of combination can be passed on to the consuming public in the form of lower prices of better goods.

It will be perceived that the cooperation of which we have been speaking thus far has been either imposed from above by governments or has been achieved through the self-interest of business men. There is another way in which cooperation has arisen, and that is through the combination of small producers or of small consumers. It is this special type of cooperation that we have in mind when we speak of the "cooperative movement".

The successful establishment of cooperative storekeeping at Rochdale

The essence of the cooperative movement is the elimination of the competitive industrial system by mutual association. The conception is that of mutual help. The movement began in those terrible early days of the factory system in Great Britain. A number of high-minded men revolted against the horrors of industrial serfdom and child slavery; and, not before human deterioration had proceeded far, legislative and other efforts were made to combat the evils. Among those men was counted a successful manufacturer named Robert Owen. In his own village and mills he showed that it was not only possible, but that it paid the manufacturer to care for his employees and to educate their children. After years of such practical experiment, he preached the gospel of coöperation to working people, counseling them to take into their own hands the control of industry. In 1824 the combination laws were repealed, and it became possible for working men to combine; 1844 saw the formation of a successful coöperative society, the Rochdale Pioneers, a famous institution which still exists. It was not the first cooperative body, for there had been a number of such efforts since about 1816, nor was it even the first to introduce the principle of restricting the rate of interest on the capital employed, and to *return to the purchaser of goods any surplus paid by him in price.* The coöperative "dividend", as it is called, is not a dividend in the ordinary sense, but merely represents what is saved over ordinary store prices through the coöperative methods of distribution.

Ten-fold growth in five years of sales of the British cooperative societies

It is impossible to trace the entire history of the cooperative movement, interesting though it is, but from 1830 onwards it has never looked back. The official statistics of the English and Scottish Wholesale Coöperative Societies indicate that in 1920 there were 1501 coöperative societies in the United Kingdom, with 4,560,000 members and with 201,500 employees. Their aggregate sales in that year amounted to over a billion and a half of dollars. As showing the especial importance of distributive coöperation (consumers' coöperation or coöperation in buying) we may note that 1380 of the societies were of that type. In the short period from 1914 to 1920 the aggregate sales of the British coöperative societies had grown nearly ten-fold.

The main part of the business is done by the retail distribution societies on the plan of the original Rochdale Pioneers — *i.e.*, they return to the customer at periodic intervals the surplus remaining over between wholesale and retail prices, after paying all expenses.

System by which coöperative distribution and production are carried on

Membership in such societies usually means simply the holding of a share sold at a low or even nominal price, and often the payment of this price or entrance fee may be deferred and taken out of "dividends" later accumulated on purchases. The retail coöperative societies are affiliated with wholesale coöperative societies, which buy at wholesale — and in some instances manufacture — and act generally as wholesale agents and suppliers to the retail distributing societies. The Rochdale plan is also followed here. That is to say, the retail society buys from the wholesale society, and the wholesale society returns to it whatever surplus of profit remains on its purchases after paying a moderate interest on capital. The retail societies, however, are not bound to buy from the wholesale cooperators, but they naturally do so as far as possible.

The growth of this working-class cooperative distributive movement, combined with an element of cooperative production, has undoubtedly been of great advantage to the working men concerned The saving of retail profit means, of course, an addition to the wages of cooperators. The practice of cooperation, each member being given the right to vote in the direction of affairs, trains workingmen in their own affairs, and gives them an insight into business The control of managers, of assistants, and, in the case of the productive societies, of industrial workers of both sexes, gives them a better insight into the nature and magnitude of the problems of the employer. In this last respect there is the continual contest between the desire to secure as large a dividend or surplus on purchases as possible and the paying of good wages to the employees; and it is claimed by cooperators that they properly discharge their duties in this respect.

Copartnership as a form of coöperation, but not like cooperative movement

Another factor of considerable interest in which the principle of cooperation is involved is the copartnership movement, which is based upon the conception of interesting all the workers of an industrial undertaking in its operations by making them actually partners in it and sharers in any profits that may accrue. It looks at the matter primarily from the point of view of the producer instead of from that of the consumer, as is the case with ordinary cooperative societies Such organizations may arise either from a combination of workmen entering into partnership with their own or with borrowed capital, or from an employer taking his employees into partnership.

The first of these two types of labor copartnerships is clearly a form of producers' cooperation, properly so called. The second type involves what is more commonly termed "profit-sharing". Some sanguine people are fain to believe that they see in profit-sharing the sure means of reconciling capital and labor in all industries.

Profit-sharing not so attractive when labor is asked to share "negative profits"

On the other hand, the critics of profit-sharing hold that its record is such as to hold out no promise of future success, except in certain highly specialized small industries, or possibly in larger industries that have a considerable degree of monopoly power. Where an industry is subjected to the constant, remorseless pressure of competition, profit-sharing, it is held, breaks down. The reason seems to be that industrial profits are necessarily associated with *risk-taking*. Profits measure business success just as losses measure business failure It is impossible to concede to laborers more than a relatively small share in the highly variable profits of any industry subject to a high degree of risk. Otherwise it would be necessary to ask them to assume also the burden of losses, which might properly be called "negative profits". Many students of these problems have concluded that it is wiser for society to bend its efforts for the present at least to increasing the stability of the laborers' position by reducing rather than increasing the amount of industrial risk he is asked to bear

Labor's claim to a share in organization and working conditions of industries

Latterly, the problem of industrial copartnership has taken on a new aspect with the growing recognition of labor's claim to some share in the management of the industry. The workingmen are not in general requesting a share in the determination of a firm's general business policies; they are interested primarily in having something to say about the general organization and conditions of the work done in the plant, and in the disposition of a host of simple but important disputes that used to be settled summarily by the employer or his representatives. Through the establishment of employees' associations, of advisory boards composed of employees, of shop committees, etc., distinct progress has been made along these wholesome and desirable lines in recent years.

History of the cooperative movement in the United States

The cooperative movement in the United States is practically as old as in England The New England Association of Farmers and Mechanics — a federation of local labor organizations — was organized in 1831 and did what it could to secure the introduction of cooperation. The Boston division of this association developed into the Workingmen's Protective Union of America, — organized primarily for the coöperative dealing in merchandise. By 1850 there were 106 branches of this organization, which later came to be known as the American Protective Union.

Successful organizations of farmers, such as the Patrons of Husbandry or "Grange" (1867) and the Farmers' Alliance (1886), introduced short-lived systems of coöperative stores, as did a number of labor organizations in much the same periods.

Although the coöperative movement of the United States is nearly a century old, the development of coöperation in its present forms is of comparatively recent origin Many of the early organizations overestimated the economies and savings inherent in cooperation, and underestimated the degree of energy and business ability which the successful management of a cooperative enterprise demands.

Recent progress of the movement must be attributed very largely to the initiative of immigrants who had brought a knowledge of coöperation with them from northern Europe. In 1920 there were some 3000 consumers' coöperative societies in the United States, each of them conducting one or more retail stores. In some places wholesale societies have been organized to supply the retail stores.

One of the strongest federations is the Farmers' Educational and Cooperative Union, which began in Texas and is strong in many other states, and notably so in Kansas and Nebraska. At Menominee, Wisconsin, a large coöperative store, organized in 1891, does a business of $4,000,000 a year. There are forty coöperative societies in the northern peninsula of Michigan. Coöperative stores have been established, with the encouragement of labor organizations, in the mining districts of Pennsylvania and Illinois.

Various immigrant groups have established their own cooperative institutions. This is notably true of the Finns, who have established not only stores, but also boarding houses, bakeries, banks, etc., on a cooperative basis. Outside of the field of retail merchandizing many other interesting experiments in cooperation have been made. Coöperative bakeries, in particular, have been generally successful. Fraternal insurance societies and mutual insurance companies of different types are common. Local or regional farmers' organizations insure against fire and other hazards. Coöperative telephone companies are often found, particularly in small communities and rural districts. A particularly interesting type of cooperative store has been established in connection with many of the larger universities and colleges of the country. These stores sell books, stationery, athletic goods and students' supplies in general. Often they branch out into other fields and carry an amount and variety of goods that would do credit to a small department store. These collegiate coöperative stores, practically without exception, have been successful. The largest of them do a business amounting to several hundred thousand dollars a year. Like most other American cooperative stores, they are based on the "dividend" principle.

Producers' cooperation in agriculture

Producers' coöperation is important in the United States, especially in agriculture. We must distinguish carefully, however, between the cooperation of independent producers — farmers, for example — and the cooperation of working men who, instead of remaining employees. decide to form an association and be their own employers. Thus, when American farmers in a given community build and operate a coöperative creamery or a coöperative elevator, they are merely engaging, as a group, in a new business ven-

COÖPERATIVE FARM MARKETING IN THE UNITED STATES

(1919 Latest Official Statistics)

Division and State	Total Number of Farms	Sales through Farmers' Organizations				Purchases thro' Farmers' Organizations			
		Farms Reporting		Amount		Farms Reporting		Amount	
		Number	Pct. All Farms	Total	Average per Farm	Number	Pct All Farms	Total	Average per Farm
United States	6,448,343	511,383	7.9	$721,983,639	$1,412	329,449	5.1	$84,615,669	$257
Geographic Divs									
New England	156,564	4,060	2.6	$5,916,681	$1,457	7,579	4.8	$3,035,806	$401
Middle Atlantic	425,147	33,854	8.0	61,224,128	1,808	17,884	4.2	6,193,647	346
East No. Central	1,084,744	144,339	13.3	132,639,450	919	83,518	7.7	14,305,931	171
West No Central	1,096,951	243,288	22.2	300,820,976	1,236	166,084	15.1	43,115,568	260
South Atlantic	1,158,976	9,517	0.8	20,639,686	2,169	12,230	1.1	2,607,639	213
East So Central	1,051,600	12,705	1.2	5,271,001	415	5,285	0.5	763,054	144
West So. Central	996,088	15,635	1.6	26,934,455	1,723	9,332	0.9	2,803,314	300
Mountain . .	244,109	12,785	5.2	17,443,431	1,364	13,875	5.7	3,769,213	272
Pacific . . .	234,164	35,200	15.0	151,093,831	4,292	13,662	5.8	8,021,497	587

ture, instead of paying commissions and profits to an outsider who might establish a creamery or provide a grain elevator. The farmers decide that by operating as a group they cannot only retain a better control over their own business undertakings, but they can also secure for themselves the profits which otherwise would have gone to an additional middleman. In many cases, however, establishments are called cooperative which are not based upon the true coöperative principle. Sometimes a small group of farmers will own and operate a so-called "coöperative creamery" to which other farmers in the same community, not in the organization, pay toll just as they would to any independent or outside operator. It is sometimes hard to say just what is coöperation and what is not. In general, however, where profits are distributed among the "cooperators" in proportion to the *amount of their business* with the association, true coöperation, in the technical sense, exists. But where the profits are distributed in proportion to the *shares* the "coöperators" hold, we are likely to find that the concern is nothing but an ordinary business corporation, even though it is conducted with more attention to the general interests of the community and with really less emphasis upon maximum profits for the shareholders than is common among ordinary business corporations.

Another field in which cooperation has shown itself efficient and is rapidly making headway is that of credit. Cooperative credit associations are common in Europe, and they are becoming increasingly common in the United States. The degree of their usefulness depends upon local conditions. But where the individual borrower, whatever his honesty and his probable solvency, has no direct contact with the banks and the other purveyors of credit, it is useful to him and beneficial to the community to have a cooperative credit association of which he and his neighbors are members standing back of him. Combination makes for strength in credit as in other departments of economic life.

Untaught or unthinking people sometimes associate cooperation with socialism. This is a mistake. The truth has been very well formulated by Mr. C. R. Fay, a competent student of the subject:

"Coöperation is not the herald of socialism, nor is it a means to combat it. The coöperative synthesis lies deeper than this. It centers about a common and original impulse of man, which inspires him, whatever be his environment, to make his weakness strength by the simple plan of joining with others who are similarly conditioned, in the pursuit of a goal, which can be attained in proportion as he is prepared to coördinate his own interest with those of his fellow-members."

FURS AND THE FUR TRADE

Astonishing Modern Developments in One of the Most Ancient of Industries

HOW FUR FARMING HAS BECOME A SCIENCE

WOMEN are the principal wearers of furs, and it is due more to their love of the soft and luxurious in wraps and dress-trimmings than to climatic necessity for warm apparel that thousands of trappers work in winter amid the snow and ice of the arctic and subarctic regions of North America and Asia.

Many of the chief cities of the United States and Canada have developed from small fur-trading stations St. Louis and Chicago, like Winnipeg, were once tiny outposts of civilization, formed by the trapper and trader as they pushed their way through forest and prairie in pursuit of new supplies of pelts. The same process went on in the Asiatic dominions of Russia until the Russian and Anglo-Saxon almost ringed the world in their quest for fur, and met in Alaska The figure of the beaver is still a conspicuous device of the escutcheon of the city of New York, where in old days beaver skins were used instead of gold and silver for currency.

In spite of the immense regions that the Canadians and Russians have brought under cultivation, it seemed, for a time, as if there was no danger of their exhausting the principal sources of fur which they possessed, although the requirements of the fur trade, in order to meet the demand which has grown at a remarkable rate in the past quarter of a century of increasing numbers and wealth of the white races, have been enormous. The people of the temperate zones, like their savage predecessors, still need warm garments to protect them from the cold and the biting winds of winter, and fashion has decreed that they shall be worn—usually quite unnecessarily if not even with discomfort—in summer. The result is that furs are more in demand today than ever before, and the fur trade and allied industries are of great importance.

A few years ago, an inquiry concerning the supply of furs from wild fur-bearing animals was addressed by the government to a large number of raw fur dealers in the United States, including Alaska. It was found that there had been an alarming reduction in the number of skins marketed during the last decade, and a demand for shorter open seasons so that fur-bearing animals shall not be trapped when they are not in their prime. The government has for some time been making a study of the situation, with a view to the development of sound state and national policies in regard to trapping, that would maintain the number of fur-bearing animals at their maximum, consistent with agricultural and commercial interests. Measures for conservation, increase and proper utilization of fur-bearing animals are now receiving attention. The ever-expanding areas of human settlement and correspondingly lessening areas of shelter for wild animals which have to seek new cover, the clearing away of the forests and the grazing of natural feeding grounds by domestic live stock, the draining of swampy areas inhabited by the muskrat, mink, otter and beaver, the more deadly efficiency in modern traps and firearms, the burning of forests, which kills large numbers of animals, or drives them to less accessible regions for their food, create conditions which make such conservation and protection a most difficult problem.

Few persons have any idea of the enormous volume and value of the fur trade, but anyone who walks in winter through the shopping districts of our great cities must be struck with the extent to which furs are worn by women and with the number of fur shops and fur sections in the department stores The wonder is where the supplies all come from, and how it is that a clean sweep has not been made of all the chief fur-bearing animals Fortunately there are certain regions in the northern parts of America and Asia where there is still a generous supply which can be maintained if good judgment continues to be exercised In the Hudson Bay territory, for instance, great care is taken not to exhaust a district when it appears to be growing thinned. The animals are left undisturbed for two or three years. Moreover, there is no trapping carried on in the breeding season or the summer months when the skins are in their worst condition Only in the depth of winter, when nature provides the animals with their heaviest and warmest coats, does the trapper operate, and his task consequently calls for exceptional endurance and a thorough knowledge of the habits of the animals. Guns cannot be used, for the shot would injure the skin; neither can poison, the effect of which is still worse The animal cannot be left too long in the trap lest its fur value be seriously diminished, and the trapper has, therefore, to keep continuously on his rounds, clearing the traps as soon as possible after the animals have been caught

SEAL-HUNTERS IN THE FROZEN NORTH

SEAL-HUNTERS HAULING SKINS TO THE SHIP

He now demands more adequate pay for his lonely and adventurous work, and this is one of the reasons for the increase in the price of furs. The hunters are no longer ignorant savages and ready to sell their dearly earned skins for beads, blankets or tobacco, representing but a small percentage of their true value They no longer barter on the principle that a musket is worth as many skins as will, when piled, equal the height of the weapon from butt to muzzle. An extended knowledge of the principles of modern commerce has regulated prices to definite market values, even between the trapper and the first consignee, so there are no fancy bargain prices for furs except under very unusual circumstances Therefore any fine fur which is offered much under the market price, may be regarded merely as a clever imitation of the real thing.

When a district is becoming exhausted, the work of the trapper grows harder, and he is ready, at a suggestion from the agent of the fur company for whom he works, to move on to a fresh camp, and thus give the old hunting ground a chance to recuperate. Besides, wild animals of some species migrate, — in Northern Canada, for instance, the lynxes follow the rabbits and white foxes travel hundreds of miles.

Among the high-grade fur-bearing animals that have suffered from overhunting are the sea otter and the fur seal. The sea otter is now becoming so rare every-

where, that only the most zealous government protection can save the species from total extinction Its dense and silky fur is exceedingly fine, and has a shimmering gloss of silver over the brown underfur. It was the royal fur of China, and only persons of high rank were entitled to wear it. A similar exemplary restriction was obtained in regard to the use of sea otter in Russia Some time ago it was not unusual for a skin to bring $2500 in China. Now the price would be much higher, for the sea otter that used to haunt the shores of the northern Pacific from Behring Sea to Mexico is almost extinct. Seven hundred thousand of them have been killed for the Chinese and Russian market in the last two hundred years, and the killing has been done in such a brutal and indiscriminate manner that the most valuable and lovely of all aquatic fur-bearing animals has been brought to the verge of extinction.

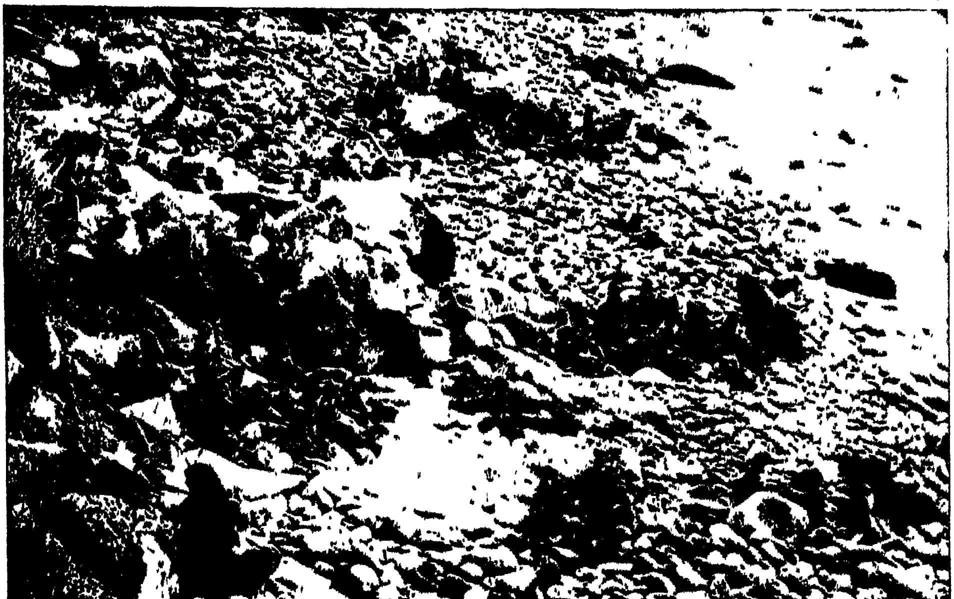


Photo U. S. Bureau of Fisheries

SEAL ROOKERY AT THE SOUTHERN END OF ST PAUL ISLAND

It is nearly a mile in length and formerly had an enormous number of seals, perhaps 500,000, but now contains only a few scattered harems, mostly of small size In the middle foreground are several "pods" of pups. When the pups are only a few days old they leave the family circle and congregate on the outskirts of the harem, where they sleep and play. This "podding" serves the useful purpose of keeping the pups out of the way of fighting and trampling bulls.

Sealskin, so highly prized by all women, is not so beautiful as the fur of the sea otter, but some years ago it was in danger of exhaustion. The fur-seal rookeries in the South Shetlands were destroyed, and the herd in the Pribilof Islands in Alaska was reduced almost to the vanishing point by poachers who used to run their boats in under cover of a fog and kill every seal they could reach Ordinarily, a seal rookery is inexhaustible, for the seal taken is only the young bachelor seal, that would be killed or driven away by the bull seals who fight savagely every season for their family group of females So long as the bulls and their wives are untouched and only the bachelors taken, the rookery will flourish, but the poachers slew females with their young The fur seal was rapidly disappearing, until, in 1911, a treaty was entered into between the United States, Great Britain, Japan and Russia which provided for the prohibition of pelagic, or open sea sealing, for a period of fifteen years. In the same year the United States enacted a provision prohibiting land killing of the seals on the Pribilof Islands for ten years As a result, the rapidly diminishing herd began to multiply. The herd at the time of the purchase of Alaska numbered over four million animals. In 1911 it had dwindled to 135,000. The agreement between the four interested coun-

tries, whereby the United States was given control and supervision of the herd and the disposal of the pelts, saved the herd. Under the management of the United States Bureau of Fisheries and the Department of Commerce, the herd increased to 605,000 in 1922, and the annual catch in the five preceding years averaged 29,000 skins of bachelor seals. These skins are sent to St Louis, where they are dressed, dyed and marketed as United States government Alaska sealskins. In 1922 the government so sold 30,000 skins valued at $750,000. The Canadian government, from territory under its control, sends out several hundred only each year Except for a small colony on Commander Island off the coast of Kamchatka, the Pribilof fur-seal herd is the only one, so far as known, in existence.

WIGWAM AND CANOE OF INDIAN TRAPPERS

DÉPÔT OF AN ENGLISH TRADING COMPANY

A new era in the history of the fur industry began with the introduction of fur farming. The first successful experiment in raising animals for their fur was made years ago, when Karakul sheep began to be bred for their pelt, and up to a comparatively recent time this was the only example of a valuable fur-bearer in captivity. The Khanate of Bokhara, West Turkestan, Central Asia, is the original home of the Karakul breeds of sheep which produce the furs known to the trade as Persian lamb, Astrakhan, baby lamb, broadtail and gray Krimmer. From these centers it has spread to parts of Persia, Afghanistan and Russia, and breeding has been carried on, on a smaller scale, in Germany, Hungary, Africa and America.

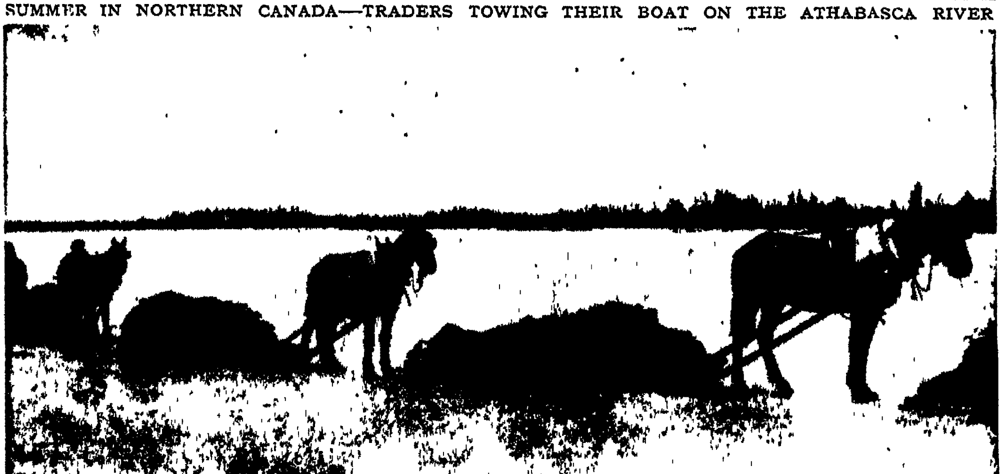
It is to the rearing in captivity of wild animals that the term "fur farming" is most generally applied This industry was evolved from early efforts of Canadian trappers to hold over animals captured out of season, until the animals, mainly foxes, became full furred. Over forty years ago such attempts were made in different parts of America, but without success

In Prince Edward Island, Quebec, Ontario and other parts of Canada, experiments went on, and after a period of discouragement and failure, the pioneer fox farmers succeeded in fixing the type of the valuable black or silver fox, which is a "sport" of the common red fox, and a new industry was born — fox farming or ranching — with Prince Edward Island, the smallest of the provinces, as its cradle. It was a business conducted in secret, principally experimenting with native silver foxes or those brought from Anticosti at the mouth of the Gulf of St. Lawrence. The knowledge that handsome profits were being made gradually leaked out, others succeeded in getting a few pairs of breeders from the pioneers, and thus laid the foundation of their subsequent fortunes. By 1910 there were about one dozen ranches on the Island, and the selling of foundation stock became general. So great was the demand that the practice of pelting ceased altogether, except where animals were accidentally killed. All available foxes were sold alive.

WINTER AND SUMMER IN THE FUR COUNTRY

ESKIMO DOG-TEAMS DRAGGING SLEDGE-LOADS OF FURS TO CENTRAL DÉPÔTS

SUMMER IN NORTHERN CANADA—TRADERS TOWING THEIR BOAT ON THE ATHABASCA RIVER

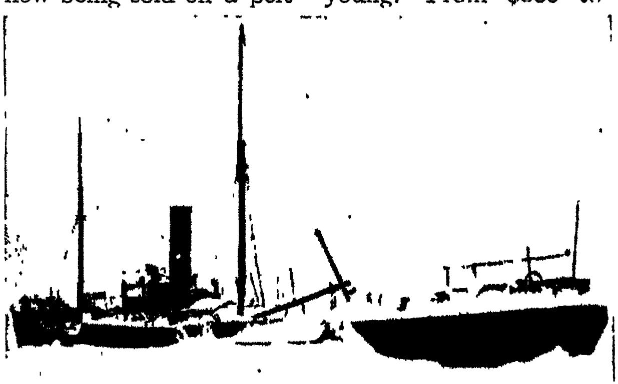


STORES ON THEIR WAY TO THE OUTLYING COLLECTING STATIONS

A period of feverish speculation began Company after company was organized, the total capitalization reaching at one time $12,000,000. The cost of a breeding pair steadily rose from $3000 in 1910 to $20,000 in 1913 When the boom was at its height, as high as $25,000 was paid for exceptional specimens. When the supply of foundation stock became exhausted, foxes were captured and brought from other parts of the country to supply the demand Optimistic speculators began investing in futures, and options were taken on the unborn pups A period of "frenzied fox finance" set in, fox men being made wealthy overnight, and the stories of those days read like chapters from the Arabian Nights. The Great War temporarily disorganized markets and practically ended speculative trading. On Prince Edward Island a reconstruction period set in, and foxes are now being sold on a pelt basis The present average value of a live fox is about $500, and for pelts $250.

A SLEDGE-LOAD OF SKINS ON THE WAY TO A DÉPOT

After receiving the remarkable price of $1800 in 1900 for a pelt, the pioneers kept the best animals for breeding, and for several years marketed only a few skins. In 1904 they began to take profits, but marketed in the next few years only thirty pelts in all, the top prices being $754, $973 and $1550 From 1907 until 1912 money from the sales of skins alone began to flow into the coffers of the pioneers, the best individual skins from the older farms realizing from $1500 to $2600.



A FUR-TRADING STEAMER ICE-BOUND IN HUDSON'S BAY

The first public corporation for the breeding of foxes in Prince Edward Island received a charter in the United States in November, 1911, and the first United States dollar invested was subscribed to this company During the past few years, fox ranching has spread from the Island to other provinces of Canada and to the United States, and more recently but still on a small scale to Norway, Japan and Scotland

On Prince Edward Island there are three hundred and eighty-five ranches scattered over an area of two thousand square miles, but mainly in two of the three counties These contain six thousand five hundred breeding pairs, almost all "silvers" and "blacks". Ten thousand pelts was the estimated sale for 1923, at an average price of $110 each — about the same number as the year's increase of young. From $800 to $1000 has been paid for single skins of exceptional quality. Eight hundred pairs were sold alive, valued at about $320,000, in 1922.

Scattered over the other eight provinces of Canada are about four hundred other fox farms, of which about fifty are in the western and prairie provinces and the others fairly well divided between Quebec (which comes first after Prince Edward Island), Nova Scotia, Ontario and New Brunswick. They contain about seven hundred foxes, principally silvers.

In the United States, there are four hundred and eighty ranches containing

twelve thousand foxes, of which all but a small percentage are silvers. The investment in the business exceeds $8,000,000. Michigan and Wisconsin lead in fox farming, which is also carried on in Maine, Vermont, Massachusetts, New York and other states, the foundation stock for the best foxes being obtained in Prince Edward Island The business at present is mainly confined to the selling of live animals

The equipment of a fox farm varies from a few improvised pens in the corner of a barnyard to a specially constructed wire inclosure of three or four acres of woodland, housing over three hundred foxes. The average ranch which is built preferably in a secluded spot, consists of a number of pens within a larger inclosure, known as the "guard fence". The pens have high walls of wire with several feet underslung into the ground and several more overlapping at the top to prevent the fox from burrowing or climbing his way to freedom. In each pen is a den for the housing of animals in severe weather and protecting the mother and her young. The den or kennel is really a house within a house, the inner chamber being insulated by a sawdust packing which keeps it warm and dry.

Most foxes are good mothers, but some have been known to kill their young or, when frightened, hide them in burrows, where they are likely to die if not found in time. In such cases, it has become a usual practice to transfer the young to foster cat mothers, and many thousands of dollars have been saved by the family tabby.

Generally speaking, foxes are fed on the same variety of foods as the house dog. They relish all kinds of meats and cereals and a special fox biscuit is now being manufactured. Milk is a popular food both for the young and for the adult.

It is the luster, fineness, richness and rarity of the silver fox which makes it a favorite among women. It is always fashionable. The term "silver fox" is the trade name for the skin of the black fox, the word "silver" originating from the presence of glistening white and gray hairs among the black. In every first-class pelt the long brush has a tip of pure white. The market for the pelts of a fine quality is practically unlimited though it is well supplied with low-grade skins. Almost four thousand two hundred silvers were placed on the fur markets in 1922, and over a million and a half foxes of other kinds.

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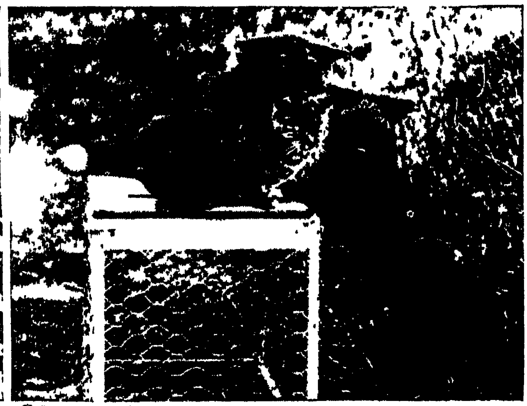
Silver fox pups six weeks old and their foster mother



© Ewing Galloway, N Y

Silver fox pups six months old and their tabbie foster mother.

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Adult silver fox

SILVER FOXES BRED IN CAPTIVITY AT CHARLOTTETOWN, PRINCE EDWARD ISLAND

A silver pelt of a wild fox will sometimes command a high price, but such occasions are rare and the vendor of skins of foxes bred in captivity has manifold advantages over the trapper of the wild He feeds and fattens his animal after an improved method, and in the month of December, when he is at his best and before the fur commences to rub or chafe, kills him in a scientific manner and thus has his fur in perfect condition. The hunter is glad to get his trophy as early as October, or as late as March, or in fact whenever he can get cunning Reynard within the jaws of his cruel trap, when the skin is almost sure to be mutilated.

While fur farming has been confined mostly to foxes of two species, silver and cross, efforts have been made to domesticate other fur-bearing animals. A few years ago, the United States government, through its Bureau of Biological Survey, initiated, and has since conducted, experiments for the practical study of silver, black blue, cross and red foxes, fishers, martens, minks, skunk and other animals which may be reared under similar controlled conditions, including beavers and muskrat These experiments have been conducted at the Experimental Fur Farm at Keeseville, New York, and at ranches of successful fur breeders. Blue foxes are also being bred successfully by the government in the Pribilof Islands, and from one thousand to twelve hundred are being "pelted" there every year.


AN ESKIMO FLESHING A SKIN

There are fur farms in twenty-five states, where, in addition to foxes, skunks, racoons, minks, opossum, beavers and martens are raised. The discovery of the fact that the latter breed the last of July, and in August, has solved the problem which has heretofore prevented the successful raising of these animals in captivity.

The practicability of beaver farming has not yet been fully demonstrated, but strong hopes are entertained that the business will develop into a profitable one. Many problems, such as family and sex relations, extent of sociability and enmity, possible diseases, protection from natural enemies and poachers, actual value and proper prices, must be worked out now that the more immediate ones of capture, feeding, breeding, fencing, control and shipping have been partially solved.

In Canada there are about fifty fur farms, other than fox ranches, in which mink, racoon, marten, skunk, beaver, and caracal are being bred. The amount received by Canadian fur farms in 1922 was $1,500,000, silver foxes representing ninety-six per cent of this amount. The Canadian Department of Agriculture is giving special attention to fur farming, and in Prince Edward Island and Quebec, fox research stations in charge of animal pathologists have been established by the government, where dietary and pathological problems and treatment of diseases are worked out. As in the case of domestic animals, breeding associations have been formed and herd books have been opened in Ottawa and Washington, in which the pedigrees of the animals are registered. The fox is now being placed in the same category as domestic animals, and the same laws are made applicable in cases of animals being stolen or shot.

The Russian sable has a high place among furs today; the best are sold from $600 to $700, the average price being $150. The finest were formerly produced in the Czar's forests. In Russia today, the best specimen is the Barguin sable found in south Siberia near the Chita district; the largest comes from Kamchatka. When it is borne in mind that a sable skin is only about ten by five inches it will be seen that a garment made of fine and well-matched skins is necessarily costly.

The mink is one of the most widely distributed fur-bearers in North America and despite insistent trapping, is holding its own It breeds readily in captivity. There are two species resembling each other closely, the European mink, or marsh otter, and the American mink The latter is found over a large portion of North America, the smallest and darkest being the small mink of Maine and the Maritime Provinces of Canada. The fur is dense and soft and the over-hair is of stiff lustrous water hair.

The annual sale of mink in London is from 80,000 to 100,000 skins, and in the United States and Canada about 200,000

Many other animals of the weasel tribe have a prominent place in commerce The Armenian white weasel was famous as ermine, a term in America applied only to the fur In Europe the pelts are used not only for ladies' wraps, but for the robes of kings and nobles and in their crowns and coronets, used at court functions and when in full regalia. Ermine has thus obtained a distinct recognition in heraldry, and the arrangement of the contrasting black tails on the pure white of the fur has been a matter of royal regulation in England from the time of Edward III, the rank of officers being indicated by the way in which the tails are placed. In uncolored heraldic engravings of coats of arms colors are indicated by conventional signs, ermine by black spots on a white field. The finest ermine in the world is the Russian and comes from Siberia. The Canadian weasel is inferior to the Russian, often having a yellowish white or gray color. Brown weasels today are more used than the white for summer furs. As is well known, the black spots in ermine are obtained by sewing the dark tails of the animal into the pelt or by intersetting it with the black paws of Astrakhan lamb. The weasel must be trapped in winter pelage, as in summer the upper part of its body is a pale, tawny brown. Stoats, when in their winter coats, are also used in making ermine. Another fur of the weasel family is that of the American skunk, which is exported in large quantities, mainly from the United States, but a few come from Argentina. About two million skins a year are marketed. The best quality is soft, thick and bluish black with a little white in the head.

The muskrat of America, the ground squirrel of Asia and the rabbit of Europe are among the largest and cheapest sources of furs. Rabbit fur is used mostly in imitation processes. It is the least durable for this, but is largely employed legitimately for making felt hats, replacing the beaver for this purpose. After the long hairs have been plucked out the fur is removed from the skin by machinery, placed in small handfuls on a tray from which it passes to a blower, which drives

PRESSING SKINS FOR EXPORT BY PRIMITIVE METHODS IN NORTHERN CANADA

the fur on a revolving copper disc and the fur accumulates and mats into a thick covering which after being removed and washed is ready for making into soft felt hats. Australia exports immense quantities of rabbit skins, several thousands of tons every year, also opossum and fox. From the Himalayas in India come otter, fox, snow leopard, snow lynx, wolf and tiger cats. The best gray squirrels come from Siberia, and they are distinguished by the luster and beautiful tone of the fur Much skill is required in matching skins. The back is the most valuable portion and the white and light gray underparts are used for cheaper linings.

One of the softest and most delicate furs in existence is the chinchilla, obtained in South America, but its skin is very thin and tender, and the fur is not durable. The commonest South American fur is that of the nutria, resembling the small beaver, and, as in the case of the beaver, the coat has to be plucked in the dressing, in which process, the long over-hairs have to be pulled out, leaving the soft thick under-hair for use. These furs are also sometimes silvered in the same way as a beaver skin is treated, by sewing silver hairs into the skin, so as to produce a charming shimmer above the natural brown Another way of adding artificial beauty to common furs is to "top" them. This is done by dyeing the top part of the hair some harmonious tint that produces a pleasing contrast to the natural color of the under part. It is the dyer who gives new beauty to all the common furs, changing them into something rich and strange. Dressers and dyers boast that so long as a rabbit lives they can manufacture a passable imitation of any known fur. Probably a hundred million rabbit skins and two or three million hare skins pass through the dyers' hands every year.

The renaming of furs in the past has been so greatly abused that the London Chamber of Commerce some years ago gave notice that misleading terms are not to be used, and offenders may be prosecuted under the Merchandise Marks Act of 1887. A similar law is in effect in the United States. However, there are permissible descriptions under which furs can be sold The American sable, though illegally sold as the real Russian sable, can be labeled Canadian sable or real sable. White rabbit often masqueraded as ermine, but is permitted to be called mock ermine. Mink, when dyed and formerly sold as sable, can pass as sable mink Generally speaking, if the assumed name has after it the real name of the fur, it may be legally sold, for example, dyed goat, which formerly sold as bear, may be labeled bear goat. Opossum can be sold as beaver opossum, opossum wallaby, sheared and dyed, as skunk wallaby; white hare as imitation fox or mock fox; nutria, pulled and dyed, as seal nutria, and so on The most notable accomplishment of the dresser and dyer in America has been the development of the muskrat for Hudson seal dyeing. About nine million skins are now dressed and dyed annually in the United States. All seal and Persian lamb skins are dyed Sealskin, after the water hair is plucked, is of a drab color, but expert dyers make it a dark brownish black.

For years the seal market of the world was London, for the secret of curing and dyeing the skins a permanent black was known only there and carefully guarded. The furriers employed as many as ten thousand people at a time, but since the Pelagic treaty in 1911, hundreds of their work people have drifted to other countries and with them the details of the method, which is no longer a secret London, however, still leads in the dressing of rabbit skins, while France and Belgium are the biggest producers of coney, the raw product in producing "electric sealskin", "clipper seal" and "Baltic seal".

Fur-bearing animals may be skinned by opening down the belly, and stretching the skins flat or open. Others are slit up the hind legs to the vent and the skin is stripped off the rest of the body. They are stretched by a board wedged inside and are said to be "cased". Fox, marten, fisher, weasel, otter, skunk, lynx, cat and muskrat are usually "cased". Racoon and wildcat are either "cased" or "open". Wolverine, badger, beaver, wolf and bear undergo the open process. The flesh and fat are removed from skins by a dull knife or hatchet.

All skins except foxes are marketed fur side inwards, the fox being turned fur side out after one day's drying, when the front legs are still pliable.

The modern method of dressing and dyeing furs is a great improvement over pioneer methods, especially in the finishing. Formerly skins were placed in lye or alkali and when they had thereby been softened, they were tubbed and shaved, by passing them over a large knife. They were next buttered and placed in a large tub of sawdust by half-naked men who trod on them for some time, the heat of their bodies rendering the leather soft and

pliable Then they were beaten out and finished Today the work is almost entirely done in large factories with special machinery for beaming, scraping, tramping, soaking, fleshing, shaving, greasing, drumming, cleaning, polishing and other forms of treatment In the dressing of furs and fur garments, England and Germany formerly led the world, but since the war, the business is carried on as extensively in the United States as it had been in Germany, and Canada is now further advanced in dressing and dyeing than England.

GRADING FURS RECEIVED IN ST LOUIS DIRECT FROM TRAPPERS

BUYERS ASSEMBLED FOR TRI-WEEKLY AUCTION OF RAW FURS BY A ST LOUIS FUR RECEIVING HOUSE

London, St. Louis, New York and Montreal are the great fur centers of the world, where auction sales are held several times a year. Smaller sales are also held in Paris and Winnipeg. Before the Great War large quantities of raw furs were collected at fairs at Frankfort-on-the-Oder in January, Irbit in Siberia in February, Leipzig at Easter, Nijni Novgorod in Russia in August, and Ishim in Siberia in December. Many of the furs, particularly those of the finer quality, were subsequently offered at the London sales Due to the war, the fur trade of the world suffered serious disruption Old fur markets, such as Nijni Novgorod, Irbit and Budapest were almost entirely obliterated and had to start again Similarly the great fur areas in Siberia and North China experienced radical marketing reorganizations. The once important fair at Leipzig also shrank to very small proportions In the past few years, though handicapped by the adverse rate of exchange, efforts have been made with some success to regain lost ground, and in 1922 the Soviet government disposed of good quantities of raw furs at auction sales in that city. The Soviets, after taking over the fur trade of European and Asiatic Russia, marketed their pelts, consisting mainly of sables, ermine, cross and red foxes, squirrels, caracals and muskrats, in Paris, London and America. In 1923 Russia exported furs valued at $5,000,000, and imported, mainly from America, skunk, mink, musk-

rat and otter The ability of the Russian coöperative societies to once more engage in handling foreign furs under Soviet sanction, indicates that the rich furs of Russia will again be available In 1923 a fair was held at Irbit, the first since 1916.

In Germany in 1923 the demand, owing to the financial condition of that country, was mainly for the cheaper furs, rabbit, skunk, nutria and opossum. The fur trade in China is beginning to revive again, after a long period of inactivity, great quantities of Far Eastern fur, lamb and kid skins coming to London and New York. Harbin and Mukden of late figured as new and important centers for Siberian, Mongolian and Manchurian furs.

The United States absorbs about 60 per cent of the silver foxes of the world, and the balance are sold mainly in England, France and other countries. The United States and France are the biggest consumers of the high-grade skins.

The demand for furs changes with the fashions, and at the New York sales in 1923 there was a greater demand for foreign furs than for American, caracals, stone and brown marten, white foxes, red foxes, from the Balkans and Turkey, and opossum being among the favorites.

The fur trade of the world runs into hundreds of millions. In 1922 the United States exported 15,000,000 skins, mostly muskrat, skunk and opossum, valued at $18,000,000, also 4,000,000 pieces of dressed and dyed skins, valued at over $7,000,000. Her total foreign trade in raw and dressed furs, manufactured or partly manufactured, amounted to about $75,000,000.

Canada's fur production is valued at over $10,000,000, beaver, muskrat, martin, mink and foxes being her principal skins.

A list of the furs offered by auction shows about eighty different kinds; muskrat, rabbit, squirrel, skunk, mole and opossum being the most numerous; with marmot, ermine, nutria, mink, racoon, lamb, fox (nine varieties), civet cat, house cat (known as "genet", the best quality coming from Holland), white hare, shiraz, wallaby, wolf, fitch, monkey, pony, beaver, kolinsky, badger, caracal, lynx, marten, sable, otter, seal, chinchilla, bear, leopard, etc., coming next in order.

The industry, like all others, has been affected by the war, but will advance again with the stabilization of currency in Europe, the improvement in international financial relations, and the carrying out of a prudent conservation policy.

SORTING FURS IN A BIG DEALER'S STOCK ROOM

CITIZENSHIP AS A STUDY

Importance of the Public's Understanding Public Rights, Privileges and Duties

THE GREATEST GAP IN EDUCATION

AS we have commented on local attempts to make each village and town approximate more and more to an ideal dwelling-place, a genuine social gathering-ground, where every citizen will help the rest and no one be a danger, and as we have discussed the relations, in administrative work, between the central government authorities and the local governments formed by the taxpayers, the doubt has recurred constantly whether today popular government is popularly understood, and, indeed, whether any serious and consistent attempt is made to cause the young to know the broad facts, or the old to reflect on the broad principles of government. In view of the extension of suffrage to all, is any adequate effort being made to give to all a clear view of sound citizenship?

Quite obviously it is necessary that, if the government of modern nations is to pass into the hands of the populace through universal suffrage — and that is what is here, or is at hand — the thought of statesmen, educators and moralists should be concentrated on giving the populace easy opportunities of understanding the foundation principles of civic justice, helpfulness and stability. In brief, the subject of civics should be regarded as the first study for every man, after he has learned how to work to support himself and those dependent on him. It has, too, a direct bearing on that work of maintenance. And yet no fully organized attempt has ever been made to give this great subject an adequate place in the scheme of education for the young, or for those on the threshold of citizenship.

Such neglect could well be understood in former days, when government was in the hands of a few — of kings and their courts, of the nobility, of the middle classes or of any limited number of selected people. There was no reason why the many should be taught to understand the value of privileges and of legal rights they did not possess, except with a view to broadening ultimately the basis of the political edifice. A haphazard knowledge might suffice for the many when it was unconnected with responsibility. But now all that is changed; and the man who has never given a minute's serious thought to public institutions or affairs will have as much voting power — though, of course, not as much influence on votes — as the profoundest publicist. The least that can be expected of the nation with a universal suffrage is that it shall take the trouble to organize a readily accessible education in the business on which the suffrage is exercised — that is, in the business of public government.

Yet it cannot be said that our efforts in this direction are at all in proportion to the importance of the end, or that the public itself takes its public duties as seriously as it should. The general tone of political discussion in this country before it entered the European war in defense of democracy was distressingly low, and public questions did not by any means excite the interest that they did a generation or two before. In the years since the war there appears to have been a "slump" to even lower levels, due in part to an inevitable reaction and moral weariness after the strain of the war period and in part to dissatisfaction with the conduct

of public affairs and the multiplied interference with what are considered private affairs carried out by the government as war measures. We must not, to be sure, place too pessimistic an interpretation on the decline of the more exuberant manifestations of political enthusiasm. The primary purpose of the old-fashioned "rally" was hardly educational. The decadence of torch-light parades, spread-eagle oratory and even joint-debates which commonly degenerated into elocutionary contests does not prove that men are thinking less about civic problems and duties. The newspaper pamphlet and mimeographed circular letter have largely replaced the spoken word as means of communicating thought, and these modern methods make less show while tending to place the discussion on a higher plane intellectually.

Not that men think less but that they need to know a great deal more

The disconcerting fact about the situation is not so much that men think less as that, under modern conditions, they need to think, and especially to know, a great deal more. There is also less direct stimulus to popular interest, less dramatic appeal, in politics than formerly. In former times the questions before governments were less complex because governmental functions were less numerous and inclusive. The issues then turned largely upon matters of square-dealing and sound ideals of justice and humanity and much less often involved intricate problems to be decided on the basis of obscure fact and masses of conflicting evidence So too it is only recently that the people have been in direct control and have been called upon to decide political questions as well as to choose between ideals and leaders. Modern political problems call for serious thought and broad information as well as for sound human impulses, if they are to be dealt with intelligently. It is in this equipment of information and trained reasoning capacity that the everyday citizen of the less educated classes is weak, and the educated man who has specialized along other lines than the social sciences is often no better provided.

The shallowness of reasoning characteristic of political "arguments"

It is discouraging to the publicist to observe the ignorance as to the fundamental facts underlying social questions and the shallowness of the reasoning characteristic of the political "arguments" which are thought good enough for the average citizen Forceful assertion and witty illustration, even more or less open appeal to prejudice, seem to be more effective than logic in carrying conviction to the popular mind. Voters look too little way beyond the ballot to its effects in governmental action, and neither the cost nor the value of political power is appreciated. They give their votes as an "honor" to a man who appeals to them or to any cause which for the moment seems to be "the thing", judging by the newspaper headlines. The tremendous rise in the cost of government and in the burden of taxation since the outbreak of the war have forced more careful attention to this phase of the matter, but here again the common citizen has little foundation for distinguishing between true and false economy, or between promises to reduce taxes which can and those which cannot be fulfilled without causing more loss than gain.

The failure to spend individual thought on public affairs

The newspapers themselves are diligent in providing ready-made excuses for a want of thought. They plant causes on their readers in much the same way that they suggest fashions to the domestic circle. They give the impression that certain things are what people are believing and thinking and doing and wearing — it is all one "swim".

That there is an immense amount of this unthinking acceptance of anything that seems to be "going" may be seen in the quality of the arguments that are thought to be good enough for the modern newspaper reader. Suggestions that no self-respecting man would dare to make in any private circle of intelligent persons — as, for example, explanations of the momentary course of public events — are brazenly

given to a silly public, because it is known that many will be quite ready to accept them without a moment's thought if they fall in with political inclination; and others will laugh at the audacity which coolly bamboozles the "tenderfoot" politician with arguments which no sane, experienced man believes in.

Is this too strong? That it is not may be put to a simple test Is there a single fallacy held by mankind in the course of their intellectual evolution that could not be advanced today in the popular press, boldly, by editorial fiat, and be received without a flicker of doubt by the read-as-you-run subscriber? Take such a fallacy as the mercantile theory, exploded for all time by Adam Smith, and who does not know that restatements of the theory are constantly received by the ordinary newspaper reader of today as Heaven-sent wisdom? The truth is that as popular government has extended, accompanied by the ministrations of the cheapened press, a real knowledge of the principles of citizenship has declined. Politics are a subject-matter of news, not of thought.

The possibility of expounding civics quite apart from immediate politics

If this statement of the position is anywhere near the truth — and we contend that it outlines very serious truth — there must be good ground for urging that civics should be made an important, regular part of our school system, and be sedulously taught in after life. By civics, of course, we mean public polity apart from the politics of the hour.

But it may be said that citizenship cannot be expounded without reference to politics, and that it would never do to have party politics involved in school curricula We suggest that there is not the slightest need for any such contingency. As religion can be inculcated entirely apart from sectarianism, so civic organization, civic principles, civic patriotism and history can be presented without any reference to the party controversies of the moment; for men of every party complexion are in essential union with regard to the great elementary conceptions of government.

The preponderating advantage of party conflict, national and local

In thus putting aside from the schools the idea of discussions that would involve party feeling, let it not be supposed that we join in the common denunciations of party warfare as something inimical to good government. In elections to Congress or a state legislature, of course, party strife will be conspicuous; and we are further prepared to defend its adoption in local contests. It is perfectly true that a large proportion of the work done by local authorities in administrative directions has no relation to national politics, as they are commonly understood Whether a new street shall be planned for the public convenience, and how it shall be paved, are questions on which party color can give no lead. And yet experience shows that even small local elections may be run with advantage on party lines, though party interests are not involved by the nature of the business to be transacted.

On the continent of Europe, and in England, the selection of a candidate by one of the political parties is something of a guarantee of the personal ability and fitness of the individual for the post. But in America, where no one, generally speaking, outside the two major parties, has much show of being elected, the candidates of the greatest personal integrity have often been independents. The large political organizations commonly choose men for their promises to the "machines" rather than for their attainments. In the elections, therefore, the citizen is confronted with a dilemma. If he votes for a party platform which has much chance of winning he must cast his ballot for an inferior candidate. If he considers the candidates on their merits he is likely to "throw away his vote" on a man who cannot be elected because he is not backed by a strong party organization and tradition. Many voters cast their ballots for independent candidates on the theory that a large independent vote will scare the party organizations into nominating better candidates and modifying their platforms along the line of reform in which they believe.

There is undoubtedly some truth in this reasoning, and the platforms and candidates of the leading parties often clearly show the influence of a desire to bid for the votes of groups small in numbers in comparison with the "regular" following of the parties It is not clear just how far the success of the "prohibition" movement illustrates the principle, for no one can say how much power the Prohibition Party exercised in comparison with other forces working toward this method of dealing with the liquor traffic. In our view a more hopeful procedure is to educate the citizen up to the necessity of taking an active part in the internal affairs of the political parties themselves.

Interest the truest touchstone and test of civic competence

Of course, in all local elections, where broader questions of political policy are not involved, many voters will favor the man who is thought to be ablest, irrespective of party color, and in that way any ill-effects of a party choice are neutralized, but the general sifting of candidates by party organizations remains a helpful part of the process of government, and one that need not be flouted or denied or disparaged Party government that does not admit of corruption is a reputable resource which is not in need of any apology. It is one of the buttresses of the civic fabric, and should be appreciated and not discounted by anyone who undertakes to interest the public in citizenship.

The true touchstone for initiatory participation in the government of a country in any capacity, whether as a voter, an administrator or a legislator, is *interest* — individual, keen and public spirited. If interest is sufficiently strong it will bring knowledge. Indeed, the right to vote should be dependent on the elementary qualification of having some personal care for public affairs. No harm would be done if every man and woman who has an individual interest in civics, and will take some trouble to show it, were allowed by personal action to register as a voter, provided nobody was registered who did not display that personal care.

A suggestion for making the franchise represent the nation's real mind

If every citizen had to appear at a public place, take out a certificate of citizenship, pay a small fee and renew that certificate every few years, something would be done towards getting rid of the farce and indignity of the utterly uninterested voter, who has to be entreated and cajoled into voting, often by people who are selfishly interested. All who care would have votes, many who do not care would leave themselves off the list, and the true opinion of the country, spontaneously formed, would be more nearly obtainable.

Now, the demand seems to be for the maximum number of voters, irrespective of interest or the knowledge that is largely a matter of interest, as if the franchise had some magic virtue apart from the exercise of real judgment. If the responsibilities of citizenship were something to be won, or formally assumed, as a member of Congress or a city alderman or a justice of the peace takes an oath, promising faithfully to perform the duties of this office, there might be more of an incentive to a thoughtful study of civics, and the need for a formal training in the principles, duties and responsibilities of citizenship would be seen without argument and met earnestly and promptly, thus filling the greatest gap in education.

On the other hand, it has been argued that the great evil is the indifference of the great mass of the citizens, who leave public questions to be settled by the professional politician and those who have some "axe to grind". In consequence there has been some propaganda in the interest of compulsory voting as a remedy for the evils of the political machine and the political boss. Our own guess in the matter was stated on a previous page. It seems to be a question of educating the mass of the citizens on the subject of the rôle which political parties play in modern government and getting them to interest themselves in the making of platforms and nomination of candidates so that when election day comes they will not be confronted by the necessity of making

a choice between evils. We must drive home to the man in the street the vital truth of the old saying that *eternal* vigilance is the price of liberty, — and not vigilance on election day only. In modern political life organizations, or "machines", are as necessary as they are inevitable, and leaders, or "bosses", are as necessary and inevitable as organizations. The citizen can direct the organization and choose and control its boss if he is made to see that these are the real power back of government and the necessary agency of democracy.

What are the broad ideas of civics that should be taught to the young, without controversy, and known by the old without doubt? We cannot, of course, cover the ground completely here, but we may indicate its range by mentioning some of the leading points.

The need for knowing what one's country stands for in the world

True patriotism and the conscientious exercise of political duties are impossible unless one's country represents to one some definite ideal of social life. Some nations have had no ideal at all except military glory, or perhaps even mere plunder. The Anglo-Saxon has always stood for justice and fair play, and wherever British rule has gone a respect for law and square dealing has gone with it. These things America of course inherited; our own contribution has been something other than these. The American ideal is to judge each man according to his own personal worth, to honor all useful labor and to find and recognize the dignity of the common man. This is what we mean by "equality", not that all are alike, but that the differences recognized by society are to be the real differences, and not some accident of birth, dress or occupation. It is America's mission to prove to the world that effective organization, unity of action and respect for authority are possible without exalting or puffing up those who command, or degrading or belittling those who obey, that those who rule and those who are ruled can meet on a level on the common ground of humanity.

In our international relations we have extended the same principle to countries. We are willing and glad that any nation should glory in its size, its power or the grandeur of its achievements; but we insist upon the equal right of the smallest or humblest nationality that feels itself distinct from others and shows itself competent to do so to rule itself under its own laws, without disturbance or interference from without. And when any people is clearly too "backward" to take its place as an independent sovereignty, the first object of a ruling people should be to encourage and assist its development to the degree of competence and responsibility requisite for freedom. The fortunes of war and the accidents of history have given us a few small colonies, but in the administration of these the above principles are being applied, and we are committed to the principle of ultimately allowing them to take their places in the family of nations if they show the ability and the desire to do so.

A special problem of citizenship in our country: the absorption of the alien

One of the chief obstacles to intelligent popular government in our country has been a large body of foreigners who, through no fault of their own, are alien to our language and institutions as by birth they are alien to our soil. Interest we have named as the first essential in civic competence, and understanding is the first requisite to interest. To the process of fostering this sympathy without social standards and ways of living has been given the name of "Americanization". Perhaps the fundamental reason back of the movement has been the notion which every people cherishes that its own institutions are best, but however liberal we may be on this point, we must recognize that a certain fundamental like-mindedness in our people is necessary to national integrity and the effective working of democracy. When we consider that over five million foreign immigrants entered the United States from 1911 to 1917 we see the vast possibilities of discord and political disintegration which lie in the "unAmericanized"

The national consciousness was awakened to the situation when we found ourselves at war with nations in which some millions of our own citizens had been born. Fortunately the alarm which was naturally felt proved groundless, as these adopted children showed their loyalty to the country of their choice as against that of which they were bound by natural ties, and established their claim to our respect and sympathy for the way in which they stood the strain.

"Mutuality" of interest, not superiority, the proper basis of Americanization

The "Americanization" of the foreigner is not the simple matter which there is some tendency to assume it to be. Experience has shown in many parts of the world that a people cannot be forced to drop one culture and take up another. Moreover, we do not wish for a dead uniformity in our citizenship, and the ideal must be to secure likeness in fundamentals while enriching our national life by the contributions which the various foreign peoples offer us. Just as the missionaries have found that they can learn much from the populations which they go out to teach, so it turns out that the need of our country and the newer elements in its population is mutual; and in this case again as in that of the missionary a willingness to learn is a necessary condition of success in teaching. Hull House in Chicago is a social settlement built up by Miss Jane Addams in the stock-yards district, a region inhabited largely by Slavic peoples. It has done a notable work in Americanization along this line of "mutuality", stimulating the foreigner's interest in American ways by taking an interest in his own culture. An attitude of superiority and contempt on the contrary serves only to disgust and antagonize. The action of some states in the period of war excitement in passing laws against the use of foreign languages is hardly designed to give the foreigner an impression of the American spirit as something to be admired and imitated.

In Akron, Ohio, a plan of educating foreigners for American citizenship has been worked out which has attracted a good deal of attention. The work was initiated by the Chamber of Commerce in 1900, but the Board of Education has since taken it over. Funds come from the general school tax. Special teachers give instruction, not only in the shops and special schools, but in the homes of the foreigners. It was discovered that most of the foreign housewives could not leave their homes long enough even to attend night school. So neighborhood gatherings in the homes were tried, and with marked success. Some of the women had been in this country for seven years without learning to speak English. Five or six hundred come into the classes to be taught how to use the telephone, to cook American foods, to care for their babies and to read. Community singing has proved to be a source of much wholesome pleasure and to promote a fraternal and hence a community or civic consciousness. Such efforts will reward our country a hundredfold in the quality and bearing of that part of our citizenry which comes to America after growing to maturity in alien and primitive surroundings.

The need to realize a national constitution as an organic growth

Of course, the student of citizenship should have acquired a general idea of the upbuilding of our national institutions and the structure of government, from township or municipality to the national administration. This he now gets, in fair outline, from his study of history and civics. But here we commonly find one deficiency. Too little attention is paid to the difference between the nominal and the actual distribution of power and functions of various governmental agencies. The American fondness for written constitutions and in particular the almost superstitious reverence which the people are taught to feel for the national Constitution augment this danger. Unless the student also goes into the actual working of the political machinery, he will gain a very inadequate idea of how America is governed from merely studying our constitutions and the statutes relating to governmental organization. There is a

vast difference between the ideal state of the political philosopher or that of the constitution maker and the actual state which has grown up and ever continues to grow and change in response to the wants and purposes of the nation, which is a product of its history. In particular, as we have already more than once hinted, the real working government of America is carried on largely by the organized political parties, though these were until recently not mentioned in any formal enactment. To be sure, we have changed this condition somewhat in recent years. Considerable headway has now been made in bringing the official descriptions of governmental machinery into line with the facts by recognizing the vital rôle played by the parties and regulating their activities in the public interest. Perhaps we shall one day come to the point of facing the inevitable fact of party leadership and shall drag the "boss" into the light of day by treating him as what he is, a public functionary. Another special and absolutely vital feature of American government not mentioned in our constitutions is the power of the courts to declare legislation unconstitutional. This peculiar arrangement was unknown to any other government in the world until it was incorporated in the constitution of the new Czecho-Slovak republic. It grew up as a natural historic development in America and has come to play such an important part in our political life that the question of "constitutionality" dominates the discussion of social legislation in many fields and makes it very hard for foreigners to understand our problems.

The need to warm our hearts by the enthusiasms of long ago

Another indispensable function of the study of history is the appreciation it should give to the citizen of the privileges he enjoys through teaching him what they have cost our forefathers. After following the long struggle for popular liberty, first for centuries in England and later the even more bitter struggle on this continent to secure and develop the rights which Englishmen had obtained, he will not find it easy to treat lightly the privilege of casting a ballot for the officials who make and administer the laws. We must take pride in as well as know the deeds of our heroes of the past, and must realize the conditions out of which our race has come if we are to see the meaning of what we enjoy. The story of Anglo-Saxon liberty is the story of the world's emancipation, as far as it has gone; for the so-called democracies of antiquity were based on slavery and were not democracies at all, according to modern ideas. And though other peoples have made important contributions to the theory of government, their spokesmen must still admit that the Anglo-Saxon lands remain the teachers of democracy to the world as well as the main bulwark of its defense when threatened by the onslaught of autocratic powers.

The need to understand what legislation can and what it cannot do

We have already commented on the difference between legislative and administrative action. Few people who are not engaged in public activities understand how wide is the gap between laws on the statute book and laws actually put into force. An enormous percentage of laws are to all intents and purposes "dead letters". Many of them were never intended to be enforced by the legislators who voted for them Some are purposely provided with no adequate administrative machinery, but are passed by the party in power to appease the clamor of one faction, and ignored after their enactment in the interest of another. Many more fail of their purpose through lack of sufficient popular interest to see that they are enforced. It is often said that the attitude toward law in America is like the attitude of the savage toward magic. It is comparatively easy to arouse sufficient enthusiasm to force the passage of a law decreeing some desirable change, but then popular interest often dies and the law dies with it. We are very much devoted to law in the abstract and too negligent of its enforcement or even indifferent to obeying it ourselves in the

particular case. There is a common feeling that "it is not my business", or that "this one time does not matter", when the law happens to cut across some pet project of our own The obvious truth is that the enactment of laws very far beyond the power of enforcement tends to undermine the respect for law and the efficacy of all law, and it is no wonder that the cynical phrase, "the rain of law", has become a common by-word in this country. The study of government must make the individual citizen appreciate that, even though one violation may not seem to matter much in itself, it is necessary to make the enforcement of law universal if it is to accomplish its purpose. He must also be made to see that government officials cannot do everything, that the cordial support of the public, even of people not directly injured by the breach of the law, is necessary to the maintenance of law and order. We are all injured, in fact, when a useful statute or ordinance is broken or treated with indifference and disrespect. And if a law is bad, it is a dangerous practice to let it die through non-enforcement; it should be enforced or repealed.

New forms of knowledge which the modern citizen requires

If the ordinary voter is to perform his task intelligently in the primary and at the polls, he must have sound general ideas about a great many things which it was hardly necessary for rulers and officials themselves to understand a few generations ago. We have emphasized the fact that governments are constantly being forced to undertake larger and more constructive programs for advancing the social welfare In this process new problems are met with, problems whose solution demands positive knowledge and clear thinking as well as good sense and uprightness. The citizen must be fundamentally straight on the general principles of economics and sociology if he is not to go astray. These are new sciences, even to students, but they deal with the fields in which by far the larger part of governmental activity is now exercised.

The voter must do more than form an intelligent opinion on the merits of campaign issues and the abstract qualifications of candidates; he must watch the elected officials to see that their pledges are carried out and observe whether the effects of policies turn out as expected. Government reports are apt to be dry reading, but if we are to have honest and efficient democratic government, the masses of the people must pay some attention to these things and take an active interest in what their officials are doing If more reports were read they would be made more readable, and those making them would be more alert in regard to the matters to be reported on as well.

Right men, rather than "rain of laws", what is needed in democracy

Our last word must take a personal turn, for, after all, public life is largely personal.

When, at length, civics has been carefully taught in schools along the broad lines faintly indicated here, and when we have a generation of voters who understand, and view with interest, the various phases of public life, the government of the country, locally and naturally, will depend largely on a choice of men. It is the manning of the public services, voluntary and official, that matters most; and part of the training in civics should be concerned with appreciation of the qualities that make genuine statesmen and sound administrators. The right men will work almost any system, however imperfect. The wrong men will fail to use the most ideal arrangements. It should be the pride of a free democracy that it knows how to choose, and has been trained how to choose, its representatives in office from those who are public-spirited beyond a doubt, incorruptible, essentially fair-minded, open to the influence of facts, businesslike in action, experienced in the work to be done, and animated by a lofty sense of the final possibilities of their country and of humanity. Only knowledge in the electorate, based on a study of civics, will enable a democracy to be established on justice.

THINKERS V

PIERRE DE FERMAT

Founder of the Modern Theory of Numbers

FERMAT was born in Toulouse in 1595, and he died in the same city in 1665. In the 16th, and more particularly in the 17th, century, many famous statesmen in Europe devoted their leisure to scientific studies, therein distinguishing themselves by great discoveries. The celebrated astronomer Helvelius was a senator of Danzig. The Grand Pensionary of Holland—Jan de Witt—was a profound geometer. Florimond de Beaune, whom Descartes placed in the first rank of the mathematicians of his time, was leader of the presidial of Blois. Fermat, himself, in the parliament of Toulouse where he became counselor in 1631, was looked upon as the profoundest lawyer of his day. The official position of these men did not allow of their sharing in the amusements of the nobility, for they were generally of a military character; and the same dignity excused them from society gatherings. Thus it happened that those who had energy beyond their work and their domestic life had nothing to expend it upon save study, and this they could enjoy without seeming to have too much leisure.

Little is known of the life of Fermat, but his reputation was that of an upright judge, who faithfully performed his duties. In 1843 the legislative chambers of France decided to republish his works, and for that purpose voted the sum of 15,000 francs, but the proposal was not carried out at the time, and the money was returned to the treasury. (In 1891, however, his works were republished by Tannery and Henry under the auspices of the Minister of Public Instruction) The act, however, is in itself significant. The summoning of three legislative chambers of a nation to vote as to the republishing of a few pages is the most flattering tribute to genius that could be offered. In science, popularity is no true test of the value of a discovery. Certain problems would never have been solved but by the efforts of genius, yet they are hardly spoken of outside learned societies—perhaps because they relate to abstract questions. Other problems, less difficult, but having to do with natural phenomena and particularly with the motions of heavenly bodies, have become—quite justly—the legitimate source of immortal fame and general recognition to their solvers. Probably Lagrange was thinking of this when he remarked with naïve sadness: "Newton was assuredly the greatest of geniuses, but he was assuredly the luckiest too: the theory of gravitation is only discovered once!" Nearly all the works of Fermat belong to the class that is the delight of professional geometers and the despair of the general public. Voltaire did not include Fermat's name in his list of famous people who adorned the century of Louis XIV; it is not to be wondered at that his name is unknown to the world at large. "The Encyclopædia Britannica", in estimating his work, says, "He dis-

covered a simpler method of quadrating parabolas than that of Archimedes, and a method of finding the greatest and smallest ordinates of curved lines analogous to that of the then unknown differential calculus. His great work *De maximis et minimis* brought him into conflict with René Descartes, but the dispute was chiefly due to a want of explicitness in the statement of Fermat. His brilliant researches in the theory of numbers entitle him to rank as the founder of the modern theory. He died in the belief that he had found a relation which every prime number must satisfy, namely, $2^{2^n} + 1 =$ a prime This was afterward disproved by Leonard Euler for the case when $n = 5$. 'Fermat's theorem', if p is prime and a is prime to p then $a^{p-1}-1$ is divisible by p, was first given in a letter of 1640 'Fermat's problem' is that $x^n + y^n = z^n$ is impossible for integral values of x, y and z when n is greater than 2."

JOHANN GOTTLIEB FICHTE
A Believer in Mastery through Education

JOHANN GOTTLIEB FICHTE, the great German philosopher, was born at Rammenau, in Lusatia, on May 19, 1762, and studied at the University of Jena, thereafter visiting other schools of learning, and enjoying, in 1791, the great privilege of converse with Immanuel Kant. In the following year he published his first book, which gained for him, in 1794, the chair of philosophy at Jena.

Fichte was an idealist, a man whose chief business in life was to show how God transcends our ideas of Him. It was therefore natural that, in 1799, he should be accused of atheism and, in consequence, should lose his professorship, and move from Jena to Berlin, where he taught privately. Those were the days of the Napoleonic terror, and Fichte proved himself a true patriot in his "Addresses to the German Nation", wherein he declared that national prosperity and health and security must be based upon a system of public education.

The year 1809 was that of Prussia's greatest misery. We may recall such tragic names as Jena, Auerstadt, and Wagram. A crushing war-tax weighed down the country, and the necessaries of life were at famine prices Everyone, from the king to his meanest subject, was compelled to make sacrifices and practise rigid economies. In this year, thanks to the natural interest of the German people in education, and, above all, to the splendid pleadings of Fichte, the government voted a large annual sum for the foundation of the University of Berlin. This was "an act as heroic as the great deeds on the battlefield, and as far-seeing as the measures of Stein and Scharnhorst". Although faced by the most terrible enemy their country had ever known, a man unbeaten and insatiable, the Prussians founded a school of learning. Even if, more than a century afterward, we had not a long debt of gratitude to pay for the knowledge which that school has gained for mankind, the foundation of the University of Berlin would remain a lesson, a monument, a noble warning, and example to patriots of all ages.

Fichte was, of course, made rector of the new university, which was opened in 1810. Three years later he contracted a fever while attending his wife, who had become ill during her service as a war nurse. The attack proved fatal, and he died on January 27, 1814.

Fichte has been popularly represented in English-speaking countries by Thomas Carlyle, who adopted his Divine Idea of the Universe. He saw the universe as consisting of the *Ego*, or I, and *Non-ego*, or that which is not I, myself. Theoretical or metaphysical science is that which concerns itself with the ego; practical science, with the non-ego, or material world; but it is only through our consciousness of the ego that the material world exists. The absolute Ego is God, who becomes manifest through all existence, which is the vesture by which the divine and infinite makes itself apparent. The whole universe is thus the visible embodiment of the divine ideas and being, and nature the manifestation of God, the animating spirit of all things. Thus, the ascent of man, as now understood, would be an unfolding manifestation of the Godhead.

Fichte, always a man of purest life, grew more religious the longer he lived. His philosophy of "transcendental realism" is not expressed in the language of today, but, in essence, is still widely accepted. Fichte's thought, though often nebulous, has had an ennobling influence; and his practical work finds splendid expression in the University of Berlin, which he founded firmly even in the midst of national turmoil.

BENJAMIN FRANKLIN
The First All-Round American

BENJAMIN FRANKLIN, the first many-sided American to make any great impression on the civilized world, and one of the earliest to be interested in science, was born in Boston on January 17, 1706, the tenth son in a family of seventeen children. His father, Josiah Franklin, who had emigrated to America about 1685, and was a tallow-chandler and soapmaker, had an idea of dedicating him to the ministry, as the tenth son, but Benjamin had little chance of preparing for such a career After two years at school, he was kept busy in his father's shop until his apprenticeship as a printer, at the age of twelve, to his brother James. There could not have been a better trade for such a lad, ingenious, resolute, and seething with mental activity. Soon he was the best printer in the office of the *New England Courant*, and, while still working at the "case", attracted attention by his original contributions to the columns of that paper and others. When James Franklin found himself in prison for writing what he thought, the apprentice Benjamin conducted the paper quite successfully, and for that purpose was released from his indentures.

After that it was not natural that he should fall again into the routine of a journeyman printer, and following his brother's release they parted, and Benjamin went to Philadelphia. There he soon became the manager of a newspaper and printing business, and began to form schemes for starting an up-to-date newspaper of his own. As a step toward this he was persuaded by the governor to visit England to gain experience and buy types, and, relying on the latter's help — which utterly failed him — he crossed the ocean and spent eighteen months there, his skill as a printer at once securing him employment.

BENJAMIN FRANKLIN AS AMERICAN AMBASSADOR AT THE COURT OF FRANCE

On his return to Philadelphia, Franklin established his newspaper, and scored not only an immediate but a permanent success. He was a born journalist, whether regarded as a writer or business manager. But his great success in this part of his life was his "Poor Richard's Almanack", which, in addition to the usual advance information, was made a repository of proverbs and sententious sayings that suited particularly an age of thrift. He sold regularly about ten thousand copies of the almanac, and it was not only translated into almost every language because of its practical fireside wisdom, but has been a mine whence almanac sayings have been gleaned for the last two hundred years.

Having become the most conspicuous figure in the little newspaper world of the colonies, Franklin naturally entered public life. Such a man was wanted. When, at the age of thirty, he became clerk to the Pennsylvania General Assembly, he had overcome the early disadvantages of his education, and was a well-read, intellectual man with wide interests, but also with a singularly practical turn of mind.

His "Autobiography", written in a large degree during old age, is one of the most interesting books in any language, telling, as it does, how the character of a distinguished man was built up — not without lapses — and the foundation of a genuine education laid broad and deep. From 1736 on, Franklin took an active part in public life He became postmaster of Philadelphia, and eventually Postmaster General for the Colonies

In 1746 he began to make the scientific researches, particularly into electricity, which entitle him to an honorable place in the story of the progress of science. He proved that lightning and electricity are the same thing, and so far came to understand their action as to suggest the protection of buildings by lightning conductors. He made a long and special study of meteorology, with a view to forecasting the weather; studied the Gulf Stream, its temperatures and its effects; and showed the heat-retaining powers of different colors.

His position in the scientific world had, in short, become of such importance and interest that, when he was sent to England in 1757 on a diplomatic mission, he was recognized as a scientist of world-wide distinction, and was given honorary degrees both by Oxford and St. Andrew's universities, and, later, the freedom of the city of Edinburgh, a fellowship in the Royal Society and its gold medal.

Franklin was highly successful as a diplomatist, and remained in that capacity five years in England. Two years after his return, he was again sent over to negotiate a settlement of the differences which finally led to war and the loss by England of her colonies. During these negotiations he was regarded as leaning unduly to the side of the mother country, but when all his efforts proved useless and war began, he cast his lot unhesitatingly on the side of resistance against tyranny.

As the war progressed, Franklin was sent to France as special commissioner representing American interests, and to arrange for French help; and he negotiated an alliance between France and the United States. Franklin remained in Paris until he was in his eightieth year, when, by leave, he retired; but on reaching home was chosen to what is now the governorship of Pennsylvania, and held the office for three years. In 1788 he retired from public life, and died on April 17, 1790.

Franklin attributed his success to diligence in business. This, he said, had caused him to stand before five kings; but it was not only the diligence that led him, while still in a distant land, to fit himself for the most delicate diplomatic work — as, for example, obtaining a fluent command of French — that accounted for his success, but great mental acuteness, a shrewd knowledge of character, and a personal charm which made admiring friends wherever he went.

There can be no doubt that if Benjamin Franklin had followed the leading of his spontaneous inclination he would have been a scientific investigator during the last half of his long life. As it was, he was only a very distinguished amateur engaged in experiments in the intervals of a busy life.

GOETHE

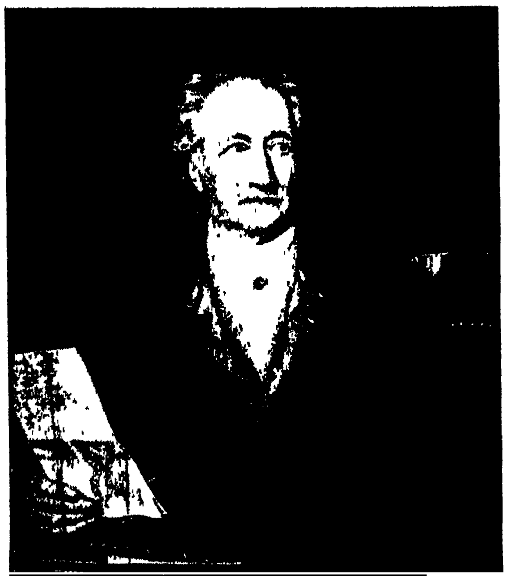
A Poet who Found Evolution by Insight

GOETHE, the greatest of all German writers, cannot be omitted from any list of men devoted to science, for it was one of the most enthralling interests of the later part of his life, and by his insight as a poet viewing life on the widest scale he arrived at a belief in evolution.

Johann Wolfgang von Goethe was born at Frankfort-on-the-Main, August 28, 1749, the son of a lawyer in easy circumstances. It was intended that he, too, should be a lawyer, but his tastes lay in quite other directions. Educated first at home, afterward at Leipzig University, and finally at that of Strassburg, his life was a series of lovemaking episodes; and, indeed, this phase of his experience continued till he was nearing his sixtieth year. Before his twentieth he was deep in poetry, lyrical and dramatic. By the end of his twenty-second he had completed his first play, "Götz von Berlichingen". His first novel, "The Sorrows of Werther", was not written until he was twenty-five. His novel "Wilhelm Meister", and his dramatic masterpiece "Faust", were written, with extensions, throughout his life — over a period of more than fifty years. It is not our concern to tell, even in outline, the story of his literary achievements. They belong to pure literature. But Goethe was not only a supreme man of letters; he was a practical administrator and man of science. Called to Weimar when he was twenty-six, he became an active public economist in the service of the duke and the state. Except for travels, he lived at Weimar for the rest of his life, died there on March 22, 1832, and there he is buried. His house is maintained as he left it.

Never was there a more all-round man. He reveled in every form of experience, and sought enlightenment through every kind of study. Nominally, he was a lawyer, but he also tried to be an artist; he was not only a dramatist, but an actor and a stage-manager. He was a profound critic, a roving philosopher, a brilliant social force; but here we are concerned only with his attitude toward science.

No scheme of philosophy can be found in Goethe's writings, but his mental attitude was a great lesson to his own day, and has remained a permanent one. He opened his heart and mind to all experience for what it was worth, rejecting nothing through narrowness and prepossession. Thus his attitude was that of the unpledged scientific inquirer. Sometimes his too great independence of judgment led him astray, and caused him to seek to overturn authorities that he could not move, as witness his long and wholly unsuccessful attempts to combat Newtonian theories.



JOHANN WOLFGANG VON GOETHE

He began the study of science at Strassburg, taking up anatomy and chemistry, with a penchant for alchemy. Later he continued his study of anatomy, and traced an evolutionary principle in the development of the human skeleton. Passing on to a study of plants, he tried to discover — though, of course, futilely — some single flower from which all others had been developed; and he pointed out that all the parts of a plant, except the stem and the root, are but modifications of the leaf.

He studied geology, but was unfortunate in taking Werner as his mentor. A great deal of time was devoted to the study of optics; and when he had passed

his sixtieth year he published a theory of colors, in opposition to Newton, which has been by unanimous consent rejected by the science of a later day Goethe, as a matter of fact, was not equipped by education for some of the scientific inquiries on which he entered, and what he saw that was fresh and valuable he saw rather as a poet than as an investigator, but his spirit of eager, all-embracing interest — seen in one who was acknowledged as the master-mind of his generation — was a stimulus to all inquirers, and his recognition of the principle of universal development prepared many minds for an acceptance of the more precise views later put forward by Darwin and others.

GEORG WILHELM FRIEDRICH HEGEL
The Greatest of the Idealists

GEORG WILHELM FRIEDRICH HEGEL, one of the greatest of German philosophers, was born at Stuttgart on August 27, 1770. When he was eighteen he went to Tübingen, where he studied theology and metaphysics There also he met his illustrious contemporary Schelling. In a very short time Hegel had to begin private tutoring in order to earn his living, but the death of his father, leaving him a small sum, enabled him to move to Jena and begin writing.

Everything that partook of the nature of mere material science was abhorrent to Hegel. Every form of empiricism or reliance upon experience was beneath the level of philosophy in his eyes. He never concealed his scorn for the monstrous fashion in which the English were then wont to call a microscope a "philosophical instrument". Thus we find him first tilting against Newton for his astronomical views. The philosophy of nature, which Hegel's friend Schelling had evolved from his inner consciousness, would not admit of the Newtonian system, and therefore the Newtonian system had to go. Here, at the very first, we see the weak side of Hegel's thought — his contempt for facts, for the fruits of experience, for the method of induction which Bacon had praised, and which all great men of science have practised. Hegel's mind was fundamentally antipathetic to all such methods, and he had self-confidence enough to attack their results, without qualifications for so doing

Hegel now joined with Schelling in editing the *Critical Journal of Philosophy*, and in the same years he met Goethe and Schiller The great poet recognized the quality of his young friend, who was no laggard in his own appreciation of other than scientific genius, and "many a gleam of luster is shed over pages of the philosopher by his frequent quotation of the poet."

Hegel was now teaching in the University of Jena, and he set himself the task of systematizing and improving upon the views of Schelling, with whom he ultimately differed, to his own great distress. In 1807 he finished his "Phenomenology of the Spirit", while the battle of Jena was being fought The university was broken up by Napoleon's victory, and Hegel went to edit a newspaper at Bamberg. Later he became professor at Heidelberg, and finally at Berlin.

His principal work, of which the first volume appeared in 1812, is called "Logic", but it deals with much more than what we now call logic. It is, in fact, a system of metaphysics, in which a philosophy, an ultimate statement of the nature of things, is evolved by the thinker through the application of logical processes. In many ways, however, the reader of today will gain less from this formidable and wordy work than from some of the later courses of lectures delivered at Berlin, especially from those entitled "The Philosophy of History", printed from students' notes.

Hegel's name stands as that of one of the greatest of the idealists. Intelligence, mind or spirit, is for him the one reality. The material world, with which the "natural philosophy" he so utterly despised concerns itself, is merely an apparatus by and in which spirit manifests itself. It is of no importance in itself, and beneath our dignity to consider. It is the object of thought, and could not exist apart from thought. It is therefore a part or creation of thought. Thus subject and object are one; mind and matter are really one. According to Hegel, "the

real is rational, and the rational is real". Therefore, if the philosopher can satisfy himself of the rationality of any assertion, that is a true assertion beyond question. Thus, the thought of *nothing* is rational, and therefore nothing, or non-existence, exists In short, "being and not-being are the same". We may sympathize with the critics who marvel that twenty serious volumes should be based upon "absurdity as a fundamental method".

The vogue of Hegelianism has passed, but the man was a great thinker, none the less. As a student of the history of man and knowledge, Hegel was a master-thinker Perhaps owing in part to the influence of Goethe, he was an evolutionist, and read history from that point of view Contrary, however, to those much more numerous evolutionists who propose to explain away the mind of man and the wonders of life by reference to the simpler and humbler forms from which they are descended, Hegel declared that man gives us the real key to the animal, and that all organic forms display and reveal what is real, though unseen, in the inorganic world We owe to Hegel the celebrated saying that the real tragedies of history are the conflicts not between right and wrong, but between right and right His works have been frequently translated. He died in Berlin, of cholera, on November 14, 1831.

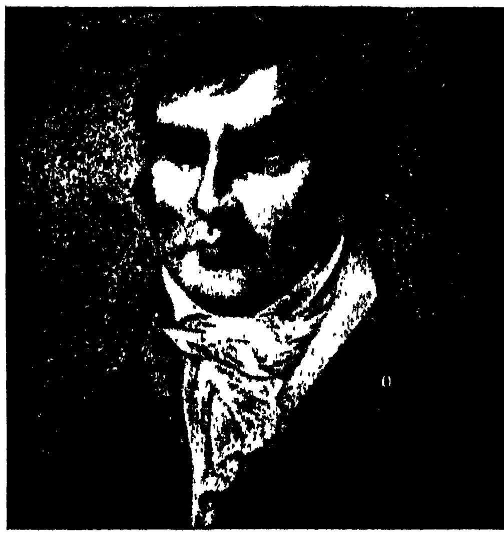
HERACLITUS
The First Evolutionist

HERACLITUS was born at Ephesus, in Asia Minor, about the year 535 B.C., and lived there throughout his life, of which little is known. He is said to have died at the age of sixty, after a life distinguished, on its external side, by contempt of show and power and fame. He declined the supreme magistracy of Ephesus, on the ground that its citizens were too corrupt. His view of men was so gloomy that, in contrast to Democritus, the "laughing philosopher", Heraclitus was called the "weeping philosopher". He is said to have left Ephesus and lived in the mountains on herbs and roots. When invited to the court of Darius, he replied as follows:

"Heraclitus of Ephesus to the King Darius, son of Hystaspes, health!

"All men depart from the paths of truth and justice They have no attachment of any kind but avarice; they only aspire to a vain glory with the obstinacy of folly. As for me, I know not malice; I am the envy of no one. I utterly despise the vanity of courts, and never will place my foot on Persian ground. Content with little, I live as I please."

From these and other stories, as to the authenticity of which no one can speak, we may argue that Heraclitus was a gloomy ascetic His writings, unfortunately, have only descended to us in the fragments of



GEORG HEGEL

his book "On Nature", and we can understand from them why it was that he gained the epithet of the "dark", or the "obscure". Nevertheless, we know enough of the thought of this strange man to assign to him a definite place in philosophy.

He enunciated, as the principle of the universe, "becoming", and, together with this leading idea, he upheld the great principle of continuity, the law of eternal consequences, which is implicit in all modern thought. Everything to him is in a state of eternal flux; "all things flow", as he said, and nothing remains. This doctrine that all things are on an ordered journey is what we call evolution today, and Heraclitus is its first enunciator.

Like all the real makers of thought, Heraclitus has suffered greatly from the misrepresentation of his critics. Even Plato, whose mind was of a very different cast, systematically emphasized those supposed Heraclitean doctrines which least truly represented him; and the great thinker of Ephesus suffers still Yet we may well marvel when we read the fragments of his work that remain. He had, in part, that idea of rhythm which we find in Herbert Spencer, the modern philosopher of evolution Fire he conceived to be the principle of all things, and as everything came from fire, so to fire must all things return. It is surprising to note how near this idea of Heraclitus comes to our modern notions of the origin of nebulæ and their history, ending with their rhythmic recreation by means of fire again. Doubtless what Heraclitus meant was to assert his doctrine of universal flux, as seen in the activity of fire. As he says, "The universe was made neither by the gods nor men; it was, and is, and ever shall be, an ever-living fire in due measure self-enkindled, and in due measure self-extinguished."

He uses other more or less metaphorical expressions for his idea of the universe as a universal becoming. "No one has ever been twice in the same stream, for different waters are constantly flowing down; it dissipates its waters and gathers them again, it approaches and it recedes, it overflows and fails." The stream thus typifies the universe at large, for "All is in motion; there is no rest or quietude".

He was a thinker in the realm of morals and conduct also. "Man's character is his fate", he said. "The law of things", he says also, "is a law of reason universal, but most men live as though they had a wisdom of their own." Here we have the sublime conception of morality as no mere conformity to law or custom, but as something grounded in the harmony and law which the thinker sees in nature. The laws of morality are not local and transient, or the arbitrary pronouncements of some deity. They are part of the laws of nature, and the philosopher must seek to deduce his moral system accordingly.

It is impossible to appreciate the real originality, profundity and courage of Heraclitus unless we try to remember the theological systems in the midst of which he lived and thought. The idea of the "laws of nature" is familiar to us, and we do not attribute the phenomena of the world to the caprices of the gods; but to teach the contrary to superstition, as Heraclitus taught in his day, was one of the greatest achievements of human mind.

THOMAS HOBBES

Defender of Autocratic Sovereignty

THOMAS HOBBES, the English philosopher and defender of sovereign power vested in kingship or other supreme form of government, lived as comfortable a life as any man ever can have lived. His joy was found in his own thoughts, and he had ninety-two years of luxurious quietude in which to think. It is true his life was coincident with all the turmoils of civil war, but they affected him little.

He was born at Malmesbury on April 5, 1588, the son of a clergyman. By the time he was twenty he had taken his degree at Oxford, and was appointed tutor to the son of a nobleman who afterward became the duke of Devonshire. Later, he was tutor to other sons of the house of Cavendish; and practically the whole of his life was spent as an honored retainer or friend of the Devonshires of three generations. He lived chiefly at the dukes' seats at Chatsworth and Hardwick, and died at the latter from the effects of a journey thither from Chatsworth.

Hobbes's consistent life as a scholar and quiet thinker was varied by friendships with the notable men of his long extended day. He was the friend of Bacon and Ben Jonson, of Galileo and Descartes. He included a king — Charles II — among the young men whom he tutored. Charles, who once cast him off because he had not defended the Divine right of kings, gave him at last a pension of £100 a year, partly because he admired his caustic wit.

To understand Thomas Hobbes and the book into which he put his philosophy of government — "The Leviathan; or the Matter, Form, and Power of a Com-

monwealth, Ecclesiastical and Civil" — it is necessary to remember that he lived through long periods when government was very unsettled, when something like anarchy reigned, and the state of public affairs was desperate as seen by a timid philosophical recluse. And so he set himself to consider what were the best conditions of stable government, wherein everyone could have comparative rest. And the theory he evolved was that such a state would most readily be found in a land ruled by royal authority absolutely, and entirely free from popular control. His distrust of democracy was deep-rooted.

The "Leviathan" of Hobbes is the State; and he argues that naturally men live in strife, every man against every other man, unless there is a power to keep them all in awe. The need for such a power is so obvious that men agree to surrender their individual rights to the State, which thus exercises a sovereignty, irresponsible in its absolutism. Only thus can security be insured. The infirmities of a commonwealth arise when the sovereign has not assumed sufficient power; and the sovereign's first duty is to surrender none of his powers The sovereignty may be in one man, or in a limited assembly, or in an assembly of all — that is, a monarchy, or an aristocracy, or a democracy, but in any case its power must be absolute and all-inclusive. Arguing on these lines, Hobbes placed the Church, as completely as the individual, under this supreme authority, whether king or democracy.

Naturally such an extreme position created an infinity of controversy. The Church denounced it, and regarded Hobbes as an open enemy. All the defenders of popular liberties were outraged, and for many years liberty found champions who distinguished themselves by showing the unsoundness of the political philosophy which Hobbes declared should be widely taught as embodying the very rudiments of good government. Though he was a shrewd thinker, Hobbes's theories count now for very little; they have become entirely out of date, but they have proved extremely useful in concentrating the opposing arguments.

DAVID HUME

A Skeptic Who Reasoned away Reason

DAVID HUME, an English philosopher and historian, was born in Edinburgh on April 26, 1711, educated at the university there, and lived in the city a considerable part of his life He was a long while settling down, as he rejected first the law and then trade as a calling, following the true instinct that his business was with books. For three years, gaining a linguistic knowledge that afterwards stood him in good stead, he lived at La Flèche, in France, in intercourse with the Jesuits, and there wrote his "Treatise on Human Nature", which contains the freshest exposition of his views. He returned home in 1737, and published it in 1739, but it attracted little attention. "Essays, Moral, Political and Religious" followed in 1742.

DAVID HUME

Between 1746 and 1749 Hume served as secretary to General St. Clair, on both military and diplomatic services, and while thus absent published his "Inquiry Concerning Human Understanding" — a recast of part of his first book. He now returned to Scotland, and published his "Political Discourses" in 1752, a book of considerable note and popularity, on which Adam Smith later based his "Wealth of Nations". Hume also in that year pub-

lished in London an "Inquiry Concerning the Principles of Morals", another re-presentation of part of his first book.

He was now becoming well known as a thinker and *litterateur*, but he failed to secure appointment to the chair of moral philosophy in Edinburgh, and the chair of logic in Glasgow He was, however, made librarian to the Faculty of Advocates in Edinburgh, and thus attained quietude and a command of books that suggested historical work. So he now, in 1754, began his "History of England", with the reigns of James I and Charles I continuing it later, forward, and then backward, till, by 1762, it covered from the Conquest to the Revolution of 1688. At the same time he wrote his "Natural History of Religion".

In 1763 Hume returned to public work as secretary to Lord Hertford's embassy to Paris, and for a time remained as chargé d'affaires In France he was a great social success, "lionized by the society ladies, fêted by the nobles, and taken by the men of letters into their friendship". On his return to England he brought Rousseau over with him, and George III — a great admirer of Hume's one-sided "History" — gave the visitor a pension. Hume, in 1766, became Under-Secretary of State and held that post until his retirement to Edinburgh in 1769, on a pension of a thousand pounds a year. Here he built himself a house on a new street named, as a joke, St. David's Street, after him, and here he died on August 25, 1776. He declares, in his autobiography published after his death, that these were the happiest years of his life.

Hume was personally such an agreeable man that he recommended himself even to people who were horrified by his ideas. He described himself as a man of mild disposition, an open, social, cheerful humor, little susceptible of enmity, and of great moderation in his passions; and he declared that though he had exposed himself to the rage of both civil and religious factions, he had no reason to complain of calumny. Yet, for two generations, he stood, with Voltaire, as the twin infidels of the world. His whole tone of mind was critical and destructive. His influence was always negative, and that so powerfully that it forced others to think in counteraction. It is through his studies in philosophy and economics that he lives, and not as a writer of history Indeed, as a historian he worked on second-hand materials, with inaccuracy and manifest prejudice, but he was the first writer in English who presented history with such grace and finish that its perusal became easy Dr Johnson declared that Hume's style was not English at all, but French, and that he only wrote in imitation of Voltaire, but Johnson admitted later that he had never read Hume's "History". Anyway, whatever criticism may hold good against it, it will not be a criticism of style. Hume wrote to please, with love of literary fame as his ruling passion.

The weakness of Hume is that he had no belief to uphold, but reveled in the ingenuity with which he undermined the beliefs of others. Berkeley had argued away the substantiality of matter, and Hume, following out a similar process, contended that no proof could be given of the existence of mind Our experience, he suggested, is based only on custom, which is the great guide of human life. We form an imaginary entity which we call the soul, but which is only a combination of swiftly succeeding ideas. Mind is nothing but a mere inference. Having thus argumentatively destroyed the mind, and made all philosophies vain, Hume asks whether he believes that the mind has disappeared; and he replies that of course he does not. We continue to think and reason, because the faculty has been antecedently implanted in the mind, though we cannot defend reason by reason. It is philosophizing that is vain; we cannot pretend to discuss the nature of essences and causes, but the primary instincts remain, though they may be contradicted by reason. Hume, in short, was a skeptic as regards philosophy, a rejecter of metaphysics as a science.

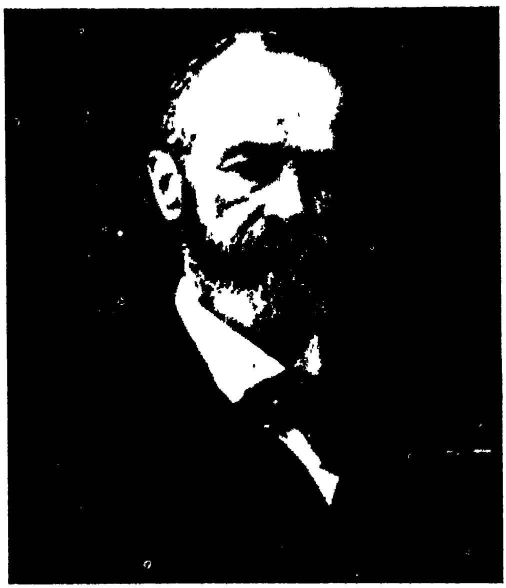
He was also a skeptic as regards religion — a point that troubled the world much more than his attitude towards philosophy. His attitude was wholly critical, whether the subject was miracles, revela-

tion or the immortality of the soul. But his iconoclastic spirit was only active in the region of abstract beliefs, when practical questions of government, involving human liberty, were under consideration, his spirit of doubting inquiry became inactive, or was only exercised against public rights, or the generous enthusiasms that have swept mankind along the pathway of progress; and he was ready to defend tyranny and absolutism of the worst kind. In thought an anarchist, he was in practical life the Toriest of Tories, though only, as Johnson said, a Tory by chance His influence on the world's thought was like that of Hobbes, inasmuch as it formed no belief, but set men thinking their way towards the beliefs of which Hume was constitutionally incapable.

WILLIAM JAMES
The Teacher of Pragmatism

WILLIAM JAMES was born in New York, January 11, 1842. His father, Henry James, was a theologian and to some extent a disciple of Swedenborg, the Swedish mystic; while his brother, also named Henry, was the well-known novelist Graduating from the Harvard Medical School in 1870, William James taught anatomy and physiology there from 1872 to 1885 In 1884 he founded the American Society for Psychological Research, and the following year he was appointed assistant professor of philosophy in Harvard University. In 1889 he became professor of psychology and a little later professor of philosophy there. During the years 1900–1901 he was Gifford lecturer on natural religion at the University of Edinburgh; in 1906 he was Lowell Institute lecturer, and in 1909 he delivered the Hibbert lectures in philosophy at Oxford University. The leading universities of the world awarded him degrees and other honors and he was elected to membership in many famous learned societies. He died at Chocorua, N. H, on August 26, 1910.

The first extensive work to come from James's pen, the "Principles of Psychology", in two volumes, was published in 1890 and eventually won for the author a world-wide reputation in that field. The "Psychology; Briefer Course", appeared in 1892, to be followed by a series of books devoted to philosophical subjects, including "The Will to Believe" in 1897; "Human Immortality" in 1889; "Talks to Teachers" in 1899; and a work on the psychology of religion, called "The Varieties of Religious Experience" in 1902. In 1900 James published two more books, "A Pluralistic Universe" and "The Meaning of Truth" "Memories and Studies", "Some Problems of Philosophy" and "Essays in Radical Empiricism" were published posthumously, the two former in 1911 and the latter in 1912. Finally, in 1920,



WILLIAM JAMES

the "Letters of William James", in two volumes, were published by his son. He himself had edited the "Literary Remains of Henry James", his own father, in 1885.

In order to understand and appreciate James's scientific and philosophical principles one must consider both the sources on which he drew for inspiration and the views which awakened his oppostion. First of all, of course, James was interested in the nature and functioning of the bodily organism, in the well-being of the natural man. As a student of the biological sciences, he came into contact with the great Agassiz and learned from this master "the difference between all possible ab-

stractionists and all livers in the light of the world's concrete fullness". English empiricism also contributed to the dislike of pure theory, which is one of James's leading characteristics as a thinker And although he grew up in an atmosphere saturated with monistic and deterministic tendencies, his own natural trend of mind was wholly in the opposite direction.

Previously to James's "Psychology" many psychologists had conceived of the mind or consciousness as made up of a bundle of sensations held together by and in some mysterious "soul-substance", and determining all the activities of the mind according to mechanical principles. But, James asserts, one has only to employ a little introspection in order to arrive at a quite different conception of the nature of consciousness In the first place one fails to discover any such "soul-substance", distinct from bodily activities, as the seat of mental activities. Secondly, the individual is directly aware of a sense of freedom quite opposed to the alleged mechanical operation of the mind as it was expounded in the old doctrine of the "association of ideas". Finally, rejecting all these pseudo-explanations and adopting as his starting-point the actual physiological factors associated with mental phenomena, James describes consciousness (including all that part of our nature which is subject to psychological investigation, the feelings, the will, perception of time and space, the emotions, habit, instinct and the rest) as a peculiar assemblage or field of elements which "comes at all times with our body as its center, center of vision, center of action, center of interest". Experience centers in my own body. Consciousness may best be described as "the experience of activity".

Now it was quite natural that James should place the greatest emphasis upon the physiological factors of our mental life, since all his training as a student led him in that direction. Moreover, he was greatly interested in getting rid of the bugbear of mental determinism, and in laying the foundation for a psychology of mind as a free agent, controlling its own destiny in so far as its activities are self-generated. Whether he entirely succeeded in his attempt or not, and whatever may be the judgment of history as to the worth of his philosophy, it is certain that the name of James will always be associated with most important contributions to the science of psychology.

Moreover, James maintains that we may apply the same principles to reality in general that have been found applicable to the nature of consciousness. Reality, as well as consciousness, is a continuous process, directly experienced, and responsive to the demands of freedom. Just as he opposed those who upheld the notion of a soul-substance as the basis of mental life, so with regard to the world as a whole James opposed those who proposed as the basis of reality in general some substratum such as the "Unknowable" of Herbert Spencer, or the "Substance" of Haeckel. With all such monistic systems James came to associate, as a necessary corollary from them, lack of freedom and despair of progress. "If everything, man included, is the mere effect of the primitive nebula (Spencer), or the infinite substance (Haeckel), what becomes of moral responsibility, freedom of action, individual effort and aspiration; what indeed, of need, uncertainty, choice, novelty and strife?"

The safeguarding of these ideals James regards of vastly more importance than the construction of a consistent system of things; the system may appeal to our intellectual sympathies, but it does not minister to other fundamental demands of our nature, James holds, and therefore it cannot be wholly true. Now it was Renouvier's masterly advocacy of pluralism, we are told, that provided James with the material for his own solution of the problem of the freedom of the will. In pluralism James finds place for the individual to assert his independence and responsibility of choice.

Instead of obeying the fixed laws of a single system, of a "Block Universe", as it were, each individual, constituting a world of his own, follows the dictates of his own will, and achieves his own salvation or destruction.

In such a conception of the nature of things the will obviously is more important than the intellect, abstractly considered. And here James owns his obligation to Bergson. It was this thinker, James states, that led him "personally to renounce the intellectualistic method and the current notion that logic is an adequate measure of what can or cannot be". All the great historical systems of philosophy are more or less guilty of this vice of intellectualism, James holds, and hence we must turn elsewhere for a more satisfactory view of the nature of truth. The solution of this problem James found suggested in the famous article on "Pragmatism" by C. S Pierce (*Popular Science Monthly*, January, 1878) The test of truth is not to be found in its satisfactoriness as a theory; rather the theory itself, and all beliefs, all doctrines, possess validity only in so far as they minister to some vital need. In James's own words, pragmatism is the doctrine that "the whole meaning of a conception expresses itself in practical consequences, consequences either in the shape of conduct to be recommended, or in that of experience to be expected, if the conception be true; which consequences would be different if it were untrue, and must be different from the consequences by which the meaning of other conceptions is expressed".

That is to say, Bergson and James maintain in common that knowledge is an instrument; it is for the sake of life; life is not for the sake of knowledge. The intellect by itself is not capable of reaching any ultimate and non-contingent truths; rather its sole function is to assist in overcoming the concrete obstacles of our daily life. And pragmatism, as James taught it, asserts that all intellectual constructions, such as scientific theories and rival philosophical systems, find their sole justification in their relative capacities to solve practical problems. Those things are true and worthy of our belief which lead to successful results. Ultimately even religious belief will be found to rest upon this foundation. Faith is just a way of expressing confidence in the final outcome of action, and a support of an otherwise feeble will.

Truth, then, is synonymous with satisfactory experience. But experience, as was pointed out above, is a continuous process, and as such constitutive of reality. Scientific understanding and even ordinary empiricism mutilate this process, break it up into artificial fragments not at all like the immediate flux of sensational life. Experience, as it is before it has been manipulated by conceptual thinking, in which the present insensibly changes into the past and makes way for the future, is thus the fabric of the real world for each of us, and it is in this world, James believes, that we independently work out our several destinies.

IMMANUEL KANT

The Philosopher who Looked Within

IMMANUEL KANT, greatest of German metaphysicians, was born on April 22, 1724, at Königsberg, the son of a saddler of Scottish descent. There he spent the whole of his long life, never traveling more than a few miles beyond its walls, and there he died on February 12, 1804. His external life, as we may surmise, was extremely uneventful. "He lived and died a type of the German professor; he rose, smoked, took his coffee, wrote, lectured, took his daily walk — always at precisely the same hour. The cathedral clock, it was said, was not more punctual in its movements than Immanuel Kant." He was a bachelor, "a man of unimpeachable veracity and honor, austere in his principles of morality, though kindly and courteous in manner, a bold and fearless advocate of political liberty, and a firm believer in human progress".

His first interests lay in mathematics and physical science. He read Lucretius, and from a passage in that author's poem he formulated a theory of the origin of the solar system by the contraction of a nebula. In after years this became the famous "nebular theory" of Laplace, but the first statement of it stands to the credit of the juvenile Kant. He also predicted the existence of the planet Uranus, a prediction which Herschel duly acknowledged when his telescope revealed the new planet.

Then came the philosophical works upon which Kant's fame rests. The greatest of these is the "Critique of Pure Reason", which was published in 1781, and which, he tells us, was the product of twelve years' meditation. It is a most difficult and unattractive book to read, loaded with terminology, and almost without form, though anything but void For some time it attracted little attention, but at length it became better and better known, and its author's disciples began to fill all the philosophical chairs in Germany. Seven years later came the "Critique of Practical Reason", the second most important of Kant's works He wrote many other books, of the translations and criticisms of which there is no end, for Kant, by general consent, is accepted as the leading figure in modern philosophy.

That is easily said, but it is not so easy to state, in a few words, the teaching of this thinker He has often been called "transcendental", and this term has led many to regard him as a mystic, and one who soared altogether above the realm of the intelligible. The proper name, however, for Kantism is the "critical philosophy". This was the name he used himself, and it indicates his essential task, which was the criticism of man's experience and knowledge. How much are they worth, what is their real validity, may we trust to them, or must we abandon ourselves to skepticism?

Kant's answer was that our knowledge is trustworthy in so far as it is based upon laws of the mind, which are true and real; but that our knowledge is limited in so far as it can only be a knowledge of phenomena or appearance, while *noumena*, things in themselves, must forever escape us. He is thus not a skeptic, who denies the possibility of knowledge, nor a "common-sense" realist, who says that things are what they seem, and there's an end on't. He occupies a middle and reconciling position, also, between the idealists, who deny the existence of the external world, and the materialists, who regard the external world as a reality. He denies the existence neither of spirit nor of the physical universe. Nay, more, he argues that our knowledge of the physical universe is only phenomenal; and that if we could know the reality of which physical things are the phenomena, we should find that reality to be spiritual too, like the knowing mind itself This is perhaps the greatest idea in all the Kantian philosophy

Time and space, for Kant, were forms of the mind, under and in which it framed and perceived and arranged external things. Hence the mind arranges things in a number of "categories", as he called them, such as unity, multiplicity, possibility, necessity and several more By further argument, he shows, the mind arrives at three transcendently important ideas — the soul, the world and God So far as the "pure reason" is concerned, these are only ideas, by no means demonstrated.

Here, however, the "practical reason", as Kant called it, enters upon the scene. In our conscience we find, said Kant, a "categorical imperative", which we are bound to obey. This furnishes the practical guide of life. It is something older, deeper, more valid than anything derived from experience It demands certain things of us; and when we try to comply with its demands we find that the ideas of God and of the immortal soul, which were no more than ideas for the pure reason, now become necessary truths for the practical reason. They are thus, and thus alone, established. The moral law within, given us by conscience, and demanding moral perfection, cannot be satisfied unless the soul be immortal; and the moral demand for universal goodness and happiness cannot be met unless a Supreme Intelligence rules the world.

Such are Kant's arguments. We observe that they are derived from introspection. The philosopher has no need to travel, to note the varieties of human experience. He looks within, observes the processes and results of his own mind alone, and reaches his conclusions accordingly. Thus, judging by his own noble personality, Kant concluded that the two most admirable objects of human contemplation were the starry skies above and the moral law within.

THE STARS IN THEIR COURSES

The Naming of the Constellations and the Making of the Map of the Sky

WHY STARS TWINKLE AND PLANETS DO NOT

WE now enter upon a vaster study The sun and its system of planets, which have seemed to be proportioned upon such a prodigious scale, must dwindle in our imagination until they become a mere point of light in the black heavens, one star among uncounted millions. Gazing at the starry skies upon a moonless night, and letting our vision wander through their brilliant labyrinth, let us realize that somewhere in that innumerable company floats a star which is our sun. Our earth and solar system are henceforward only our standpoint and observatory.

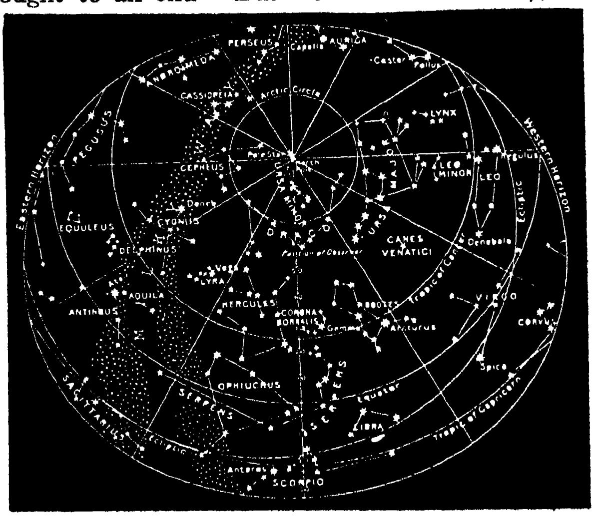
Viewed from this drifting point in infinite space, all the host of heaven are seen projected upon the interior of a hollow sphere; and so projected, they fall into various patterns or figures, of which the more conspicuous have been known from ancient times as "constellations". These figures are quite arbitrary, for the most part, though not always, revealing no astronomical relationship between the stars which enter into each of them. They do not necessarily show actual nearness of the stars which form them; for the stars are seen in perspective, so that of two which appear quite close together upon the hollow sphere, one may be immeasurably away behind the other.

Again, the stars might have been grouped in quite other figures than those that have been handed down to us by tradition. Indeed, the present arrangement is, in many cases, not the most convenient which might have been made. Sir John Herschel said of it that "the constellations seem to have been almost purposely named and delineated to cause as much confusion and inconvenience as possible Innumerable snakes twine through long and contorted areas of the heavens where no memory can follow them; bears, lions, and fishes, large and small, northern and southern, confuse all nomenclature"

This, however, is the language of exaggeration Only eighty-five constellations are recognized by modern astronomy, and divide among them the whole area of the celestial sphere; and the confusion which is caused by their irregularity is as nothing to that which would arise if astronomers were free to invent at will new combinations of stars. Moreover, the very antiquity of the constellations, of which many were fixed by early Chaldean star-gazers, deserves our respect. The names of Orion, the Pleiades and others, are as old as literature.

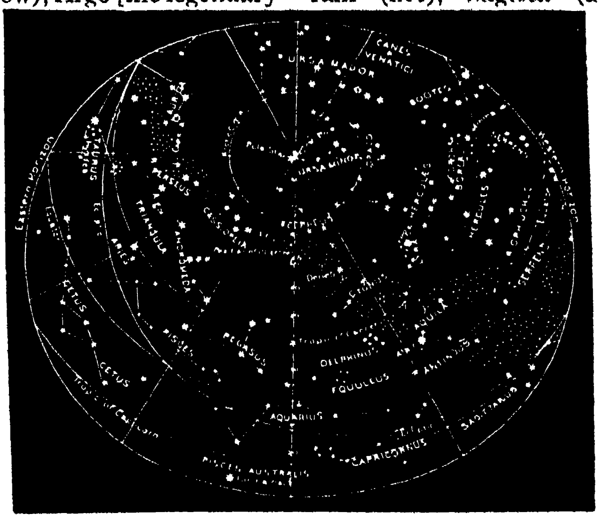
A Greek astronomer, Eudoxus of Cnidus, wrote a treatise upon the stars, dividing the heavens into the constellations as these were known in the fourth century B C. He enumerated forty-five groups of stars, but the number was increased to forty-eight by Ptolemy of Alexandria, in the second century A.D. From this time the system of constellations remained fixed until it was revised by Johann Bayer, who published in 1603 a chart of the heavens which, for that age, was wonderfully complete. Besides adding twelve new constellations to those already accepted, Bayer devised the method by which the stars in each constellation are individually distinguished by letters of the Greek alphabet in accordance with their brilliancy, the most brilliant being described as α, the next as β and so on.

A considerable number of other constellations were added by Tycho Brahe and succeeding astronomers until the middle of the eighteenth century, when the process was fortunately brought to an end But the precise boundary lines of the constellations remained undetermined until this work was undertaken in 1840 by a committee of the British Association. The whole hollow sphere of the sky was by this committee definitely divided by unmistakable boundaries into the irregular areas of the various constellations.



THE CONSTELLATIONS VISIBLE IN SPRING
As seen at midnight about the middle of May

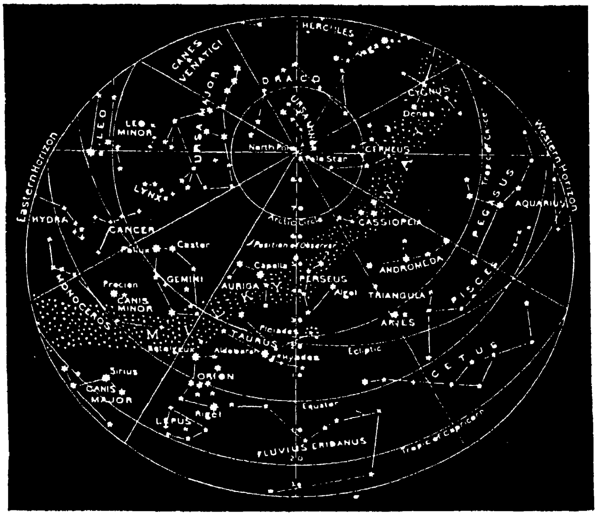
These constellations, or "asterisms" as they are also called, are as follows Andromeda, Antlia (air-pump), Apus (bird of paradise), Aquarius (water-carrier), Aquila (eagle), Ara (plow), Argo [the legendary ship, subdivided into Carina (keel), Puppis (poop), Vela (sails) and Malus (mast)], Aries (ram), Auriga (charioteer), Boötes or Arctophylax (the bear-keeper), Camelopardalis (giraffe), Cancer (crab), Canes Venatici (hunting dogs), Canis Major (greater dog), Canis Minor (lesser dog), Capricornus (goat), Cassiopeia, Centaurus (the centaur), Cepheus, Cetus (whale), Chameleon, Circinus (compasses), Cœlum (heaven), Columba (dove), Coma Berenices (hair of Berenice), Corona Australis (southern crown), Corona Borealis (northern crown), Corvus (crow), Crater, Crux (cross), Cygnus (swan), Delphinus (dolphin), Dorado (goldfish), Draco (dragon), Equuleus (foal), Eridanus (name of an ancient river), Fornax (kiln), Gemini (twins), Grus (crane), Hercules, Horologium (clock), Hydra, Hydrus (water serpent), Indus (Indian), Lacerta (lizard), Leo (lion), Leo Minor, Lepus (hare), Libra (scales), Lupus (wolf), Lynx, Lyra (lyre), Mensa (table), Microscopium (microscope), Monoceros (unicorn), Musca (fly), Norma (rule or square), Octans, Ophiuchus, Orion, Pavo (peacock), Pegasus, Perseus, Phœnix, Pictor (painter), Pisces (fishes), Piscis Australis (southern fish), Piscis Volans (flying fish), Reticulum (net), Sagitta (arrow), Sagittarius (archer), Scorpio (scorpion), Sculptor, Scutum Sobieski (shield of Sobieski), Serpens (serpent), Sextans (sextant), Tauras (bull), Telescopium (telescope), Toucan, Triangulum (triangle), Triangulum Australe (southern triangle), Ursa Major (greater bear) — also called as well the Plow, Charles's Wain, or the Dipper, Ursa Minor (lesser bear) — also called the Little Dipper, Virgo (virgin), Vulpecula (little fox).



THE CONSTELLATIONS VISIBLE IN SUMMER
As seen at midnight about the middle of August.

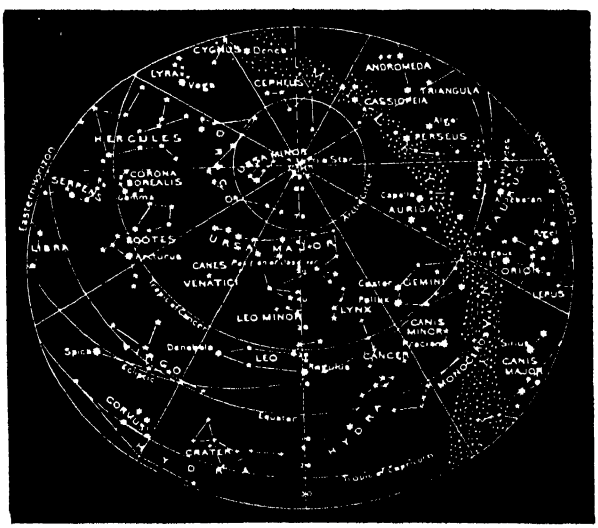
It is a queer list of names, mostly "a menagerie stocked from the banks of the Euphrates", with a few names of mythical

heroes, and a few objects of human handiwork. Strangely enough, there is not one constellation named from the vegetable kingdom, not an oak nor lily nor rose, as if these ancient Chaldeans had eyes only for beasts. Giordano Bruno suggested naming the constellations all over again, with the names of the virtues, and Julius Schiller, not long afterwards, would have changed them into monuments to the saints, but they are better left as they are No modern could have named them so exuberantly; our eyes see only geometrical figures



THE CONSTELLATIONS VISIBLE IN AUTUMN
As seen at midnight about the middle of September

Not only constellations, but individual stars also, have names; some grand, as Sirius and Arcturus; some uncouth, yet magnificent too, as Betelgeux, Aldebaran and Fomalhaut. These last are Arabic, memories of the time when the Arabs were the first mathematicians and astronomers of the world. But such kingly names as these are not for modern science; we now designate them by their serial number in some catalogue or according to some other equally practical but wholly unimaginative scheme.



THE CONSTELLATIONS VISIBLE IN WINTER
As seen at midnight about the middle of February.

The number of fixed stars which are visible under the most favorable conditions, without telescopic aid, in the entire sky of the north and south hemispheres, is estimated at less than seven thousand. But the observer in any one position on the earth's surface cannot see more than about two thousand stars, even on a perfectly clear and moonless night, because many, visible were they overhead, are hidden by the deep atmosphere towards the horizon. The atmosphere cuts off the light of a vast number of stars; if it were removed we should see eight or ten times as many. With an ordinary field-glass a vastly greater number of stars can be seen than are visible to the naked eye. The smaller stars are far more numerous than the larger; so in general the total light given by stars of the second magnitude is more than that given by those of the first, and from stars of the third class more than from those of the second, and so on throughout the first eight or ten magnitudes. The stars which are invisible to our eyes shed more than three times as much light upon a starlit scene as those which can be separately perceived, and the total amount of starlight, according to careful measurements made by Yutema and Rhijn, is equal to one-200th of the light of the full moon. It is impossible to give more than a very rough estimate of the total number of stars which are visible by means of the

most powerful telescopes; sixty millions has been accepted as a probable figure by several good authorities. This estimate was made when the largest telescopes had apertures of 36 and 40 inches, but as still larger ones are made this number must be increased, and if the theoretical limits are reached a 100-inch telescope, the largest now in existence, should bring within our vision some 180,000,000 stars It must be remembered that the number of stars visible is definitely limited, because otherwise the nocturnal heavens would blaze with light like the face of the sun. Besides the stars which are visible in our telescopes, there are many others, how many it is impossible for us to say, which are too faint to be seen, or even to be photographed

Magnitude in astronomy a term not indicating size but brilliancy of a star

The magnitude of a star is a term denoting its degree of brilliancy as seen from the earth, and does not indicate what the actual size of the star may be. The apparent brilliancy of a star depends on three factors — its actual size, its actual brilliancy, and its distance from the observer. In the vast majority of cases not one of these factors is known A star which is actually large and brilliant in comparison with others may yet appear less brilliant than they, if it is much further away from us than they are.

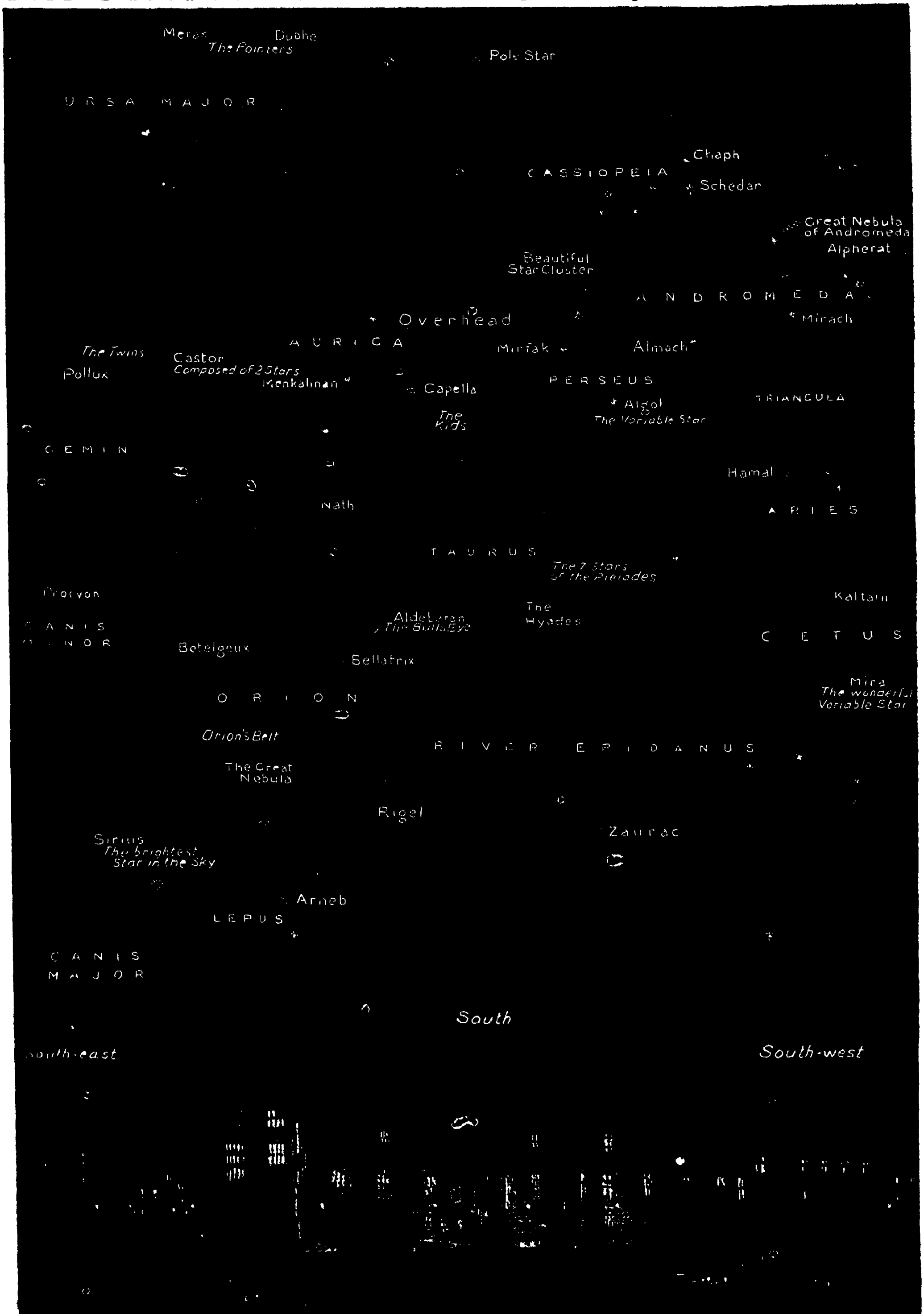
The stars which are visible to the unaided eye were divided by ancient Greek astronomers into six classes; and their method of classification, made more precise and extended to include the less brilliant stars which are visible only by means of the telescope, is in universal use today. The brightest stars are those of the first magnitude, of which there are ten in the northern and ten in the southern hemisphere of the heavens; those which are just visible without the aid of instruments are of the sixth magnitude; and the stars which are intermediate between these two classes are graded as being of the second, third, fourth and fifth magnitudes. The stars of the first and of every succeeding class differ of course greatly in brightness among themselves, because this classification is quite arbitrary, so that a star which is just within the first class may be but little brighter than a second magnitude star which is among the most brilliant of its class Yet an average brightness for each class may be estimated; and when this is done, it is found that an average first magnitude star is about one hundred times as bright as an average star of the sixth magnitude. This implies that each magnitude is very nearly two and a half times as bright as the next succeeding magnitude, and the same proportion holds all through the scale A star of the first magnitude is one hundred million times as bright as a star of the twenty-first magnitude.

The minute classification of stars by their brightness

In view of the fact that the stars of any one class differ among themselves to such an extent that one of them may be more than twice as bright as another, the classification is now made more exact by admitting decimal figures. Thus, besides the magnitude 2, we may specify stars as being of the magnitudes 2 1, 2.2, etc, in a descending scale of brightness, down to the magnitude 3. And further, in view of the fact that the twenty stars included in the first class differ among themselves to a degree much exceeding the limits of a magnitude in other parts of the scale, it has been found necessary to establish a magnitude zero to indicate two and a half times the brightness of the normal first magnitude; and above zero, again, the magnitudes of minus one, and even minus two, have been used to express the brightness of Sirius and of the planet Jupiter respectively.

Among the stars of the first magnitude are Achernar (in the constellation Eridanus), Aldebaran (Taurus), Altair (Aquila), Antares (Scorpio), Arcturus (Boötes), Betelgeux (Orion), Canopus (Argo), Capella (Auriga), Alpha Centauri (Centaurus), Deneb (Cygnus), Fomalhaut (Piscis Australis), Pollux (Gemini), Procyon (Canis Minor), Regulus (Leo), Rigel (Orion), Sirius (Canis Major), Spica (Virgo), Vega (Lyra).

THE STATELY PAGEANT OF A JANUARY SKY



THE CONSTELLATIONS AND PRINCIPAL STARS, DRAWN IN THEIR DIFFERENT MAGNITUDES, VISIBLE IN THE NORTHERN HEMISPHERE ON ANY EVENING IN THE MONTHS OF JANUARY AND FEBRUARY

The use of photography in the measurement of brilliancy

The degree of brilliancy which is possessed by any star may be estimated by comparing it with other stars without the aid of instruments for measuring light, and an experienced observer can in this way arrive at wonderfully accurate results In general, however, a photometric instrument of some kind is used Photography affords a fairly trustworthy method of comparing the brilliancy of stars which appear upon the same plate, except when the stars differ in color and therefore in photographic activity; hence there are two scales of magnitudes used, the photographic and the photovisual. Those commonly employed are the visual

Although the stars are in effect only points of light and not surfaces, yet a brighter point of light comes out in a photograph as a larger spot of light than the spot which is made by a less brilliant point of light More exact measurements of brilliancy may be made by sliding a tinted glass of gradually increasing thickness across the eyepiece of the telescope, and noting the precise point at which the image of the star disappears altogether; and other more complicated photometers using a selenium cell or a photo-electric cell are now widely employed for the determination of star magnitudes when the highest possible precision is necessary.

Why stars twinkle most vividly nearest to the horizon

A rough and ready way of distinguishing fixed stars from planets is afforded by the fact that the former scintillate or twinkle and the latter do not do so. Not indeed that the twinkling has its origin in the fixed stars themselves. It would be absurd to suppose that these vast and distant suns could flare up to blazing brilliancy and die down almost to darkness many times in the period of a second, or change their color to every tint of the rainbow within the same interval. The effect of scintillation arises from unevenness in the terrestrial atmosphere through which the starlight passes

Stars which are distinctly overhead do not twinkle at all; and the glancing, flashing, many-colored appearance of their rays increases in proportion as they are low down towards the horizon, so that their light travels through a greater thickness of our atmosphere. They twinkle more vividly on cold than on warm nights, and when the barometer is high rather than when it is low, as on a clear, frosty night; yet excessive scintillation shows that there is much moisture in the air and may be taken as an indication of approaching wind and rain. A clear relation has also been discovered between the twinkling of stars, and the aurora borealis and other magnetic disturbances; similar conditions affect both.

But although conditions of several different kinds tend to increase the unsteadiness of starlight, they all produce this effect by the refractive power of the atmosphere upon light. We see a star through many miles of a changeful medium, of which some portions are warmer than others and some more humid than others, so that the fine thread of light from the star to the eyes is broken and split up into its component colors by innumerable tiny movements in the air. The variegated colors are most vivid in the whitest stars, because the light of white stars contains more of the colors of the spectrum than are contained in the light of yellow, orange or red stars. By means of the ingenious instrument the scintillometer it has been found that the changes of color caused by the twinkling of a star take place far more rapidly than can be appreciated by the eye, and are as frequent as fifty to eighty per second.

The reason why the planets shine with a steady light

The reason why planets hardly twinkle, if at all, is to be found in the fact that they are so vastly nearer to the eye than are the fixed stars. Therefore, though they may appear to be mere points of light, they actually present a sufficiently extended disc to neutralize the effects of atmospheric disturbances. Thus, though the rays from each portion of the disc are subject to separate twinkling, the general effect is that of a steady light, because when some rays

fail their place is taken by other rays. A fixed star, on the other hand, however vast it may be, is so distant that it reveals no real disc even though examined through the largest telescope, any apparent disc which may be formed being due either to inherent limitations or to positive imperfections of the instrument.

We are apt to suppose that the stars which are so thickly scattered over the sky are all of one kind, all similar to one another. No impression could be more mistaken. Not only are they of many different kinds, but they show individual differences of extraordinary interest. They have to be studied one by one. Let us take as an example one small region in the constellation Andromeda, which for alphabetical reasons came first in our list. It has three bright stars of the second magnitude, arranged almost in line. One of these, Almaach, the third in order of brilliancy, looks like any other star. In fact, however, it consists of three stars, not merely appearing by perspective at the same spot, but physically related to one another. The chief of these is an orange-colored star, and around this there revolve a pair of stars, tinted green and blue respectively. Not far from Almaach is the radiant point of the Andromedid shooting stars Close to it also is the vast spiral nebula, visible to the unaided eye, which is traveling toward the earth at a speed of seven miles a second. In the midst of this nebula a bright star came into being in August, 1885, and faded out into nothingness within six months.

Some of the quite unexpected sights of the heavens through a telescope

Or consider the Pole Star, familiar to everyone as marking very nearly the northern point in the heavens. It is a star of the second magnitude at the end of the tail of the Little Bear. This star, whose light is nearly fifty times as great as that of our sun, is closely related to a star of the ninth magnitude near to it, and moreover has two attendant dark stars, one of which revolves around it in about four days, while the other, more distant, takes twelve years for each revolution.

Or, again, the constellation Aquarius shows us no stars even as bright as the third magnitude, but on looking into it with the telescope we find a double star, the pair revolving round one another in about sixteen hundred years; a magnificent globular cluster of stars like a swarm of glittering bees; a pale blue nebula; and other equally varied celestial objects.

The bewildering variability of stars, great and small

In Aquila, again, a constellation which is traversed by the Milky Way, we find a variable star whose light alternately gleams out and is cut off through a constantly recurrent period of seven days. In this same constellation have arisen at different times three "new stars" of exceptional brilliancy, the most recent of which is fully described later on (Chapter 31)

In Auriga, the mighty star Capella, which is a hundred times as bright as our sun and rushing away from us at the rate of 19 miles a second, is found to consist of two vast luminaries revolving round one another in one hundred and four days. Another pair of stars in the same constellation revolve round one another in four days; and yet another star varies in brilliancy with bewildering and unaccountable irregularity.

The star Beta Orionis is a prodigious sun having a luminosity 13,000 times that of our own sun. In Canes Venatici, the Hunting Dogs which pursue the Great Bear, the chief star appears to the unaided vision as a mere speck of light; but the telescope shows that this speck consists of two great suns, one yellow and the other lilac.

The wonderful variety of the stars, seemingly inexhaustible

The variety of the stars is inexhaustible. Sirius, the Dog Star, in the constellation of Canis Major, is a bright white luminary which has given the name of Sirian stars to many distant suns of similar color and constitution. Sirius was worshiped by the Egyptians as the star sacred to Isis, and was dreaded by the Romans as ruling the Dog Days, or greatest heats of summer.

The innumerable double stars, and their complicated movements

In Capricornus the chief star can be made out, by unaided vision, to be a pair of stars; but the telescope shows that one of these consists of two stars and the other of three, all five of them moving in close relation. It is evidently a mistake to regard our own sun as a pattern of all stars; it is of one kind among many others, and its position is perhaps isolated in an unusual degree

Double stars of all kinds are innumerable, and the periods of their revolutions vary without limit. Every constellation shows examples of them Thus in Cassiopeia, the bright constellation shaped like the letter W between Andromeda and the pole, we find a double star revolving once in two hundred years; and the chief star of Centaurus is a pair revolving once in seventy-nine years, the two members of the pair being twenty-three times as far apart as our earth is distant from the sun This pair, Alpha Centauri, are our nearest neighbors in space, their light taking only four years and four months to travel to the earth

The constellation Cepheus is of interest, because its principal star will be the Pole Star after five thousand years from now. Cetus, the Whale, besides having many brilliant nebulæ, includes the wonderful star Mira Ceti, which was the first periodical star to be discovered; its changes recur with some irregularities in about three hundred and thirty-one days, during which time it emerges from dimness to great brilliancy, and fades away again Corona Borealis, the Northern Crown, between Boötes and Hercules, has a star which is partially eclipsed every three and a half days, another which varies greatly in brilliancy at quite irregular intervals, and three binaries, or double stars.

It is easy to learn the principal constellations with the aid of a star map and a few evenings, at different times of the year, spent in studying the sky A precise knowledge of all the groups and of their intricate boundaries is, however, unnecessary for the layman.

The mapping and cataloguing of the stars by the use of photography

In former days stars were designated solely according to their constellation, and this is still done to a large extent: but the smaller stars are now known principally by their numbers in certain star catalogues, which give their right ascension and declination, analogous to the longitude and latitude of terrestrial geography, or their relation in the heavens to other stars whose situation is well known An immense amount of labor has been given to cataloguing the stars, and the precise position and magnitude of over half a million stars are now recorded and available for reference. This work has been largely done by photography, which becomes every day more important in astronomical work The great chart of the heavens, prepared by collaboration in various parts of the world, involves the exposure of twenty-two thousand photographic plates so as to cover every part of the sky.

The unread maze of heavenly movement that will be deciphered some day

The determination of the precise position of every star has become much more important since it has been discovered that the stars are drifting in various directions and at various speeds, and are moving in some cases more swiftly than the earth in its orbit Thus Barnard's star drifts through more than ten seconds of space every year, and several others move at speeds approaching this Arcturus has a yearly motion of over two seconds, and Sirius of more than one second; and these speeds, though they make but little annual difference in the star's apparent position in the sky, answer to tremendous actual velocities, reaching in some cases to hundreds of miles per second. Even those stars which at present seem to us to be at rest are doubtless really in motion, their apparent fixity being due to their almost unimaginable distances from us. Moreover many stars are combined with others in these movements, showing signs of vast systems at whose nature we can hardly guess.

MOUNTAIN STOREHOUSES

The Great Ranges of All the Continents and the Solitary Peaks

EFFECTS ON NATURE AND THE MIND OF MAN

TO the unscientific mind mountains are symbols of immensity and immutability, and men at all times and in all lands have regarded them with reverence, awe and superstition On Mount Olympus were throned the gods; on Parnassus dwelt the Muses; on Mount Etna were intrenched the Titans; on Mount Hira, Mahomet conceived his religion. Further east still we have the sacred mountain of Fujiyama, in Japan; while on Mount Meru sat the gods of India.

Even in modern, matter-of-fact times mountains arouse sublime emotions. Thousands go to the Canadian Rockies, to Norway and Switzerland, not merely to breathe the mountain air, but also to get spiritual refreshment from the mountain scenery.

Every poet, every painter, has been inspired by the mountains, and some of the noblest pictures in art and some of the finest passages in literature have been born of the mountains. Were the earth flat it might be beautiful, but it would have much less grandeur and much less sublimity. Ruskin in a fine passage imagines a beautiful flat country suddenly becoming mountainous He imagines a great plain, "with its infinite treasures of natural beauty and happy human life, gathered up in God's hands from one edge of the horizon to the other like a woven garment, and shaken into deep falling folds, as the robes droop from a king's shoulders; all its bright rivers leaping into cataracts along the hollows of its fall, and all its forests rearing themselves aslant against its slopes, as a rider rears himself back when his horse plunges; and all its villages nestling themselves into the new windings of its glens, and all its pastures thrown into steep waves of greensward, dashed with dew along the edges of their folds, and sweeping down into endless slopes, with a cloud here and there lying quietly, half on the grass, half in the air; and he will have as yet, in all this lifted world, only the foundation of one of the great Alps And whatsoever is lovely in the lowland scenery becomes lovelier in this change"

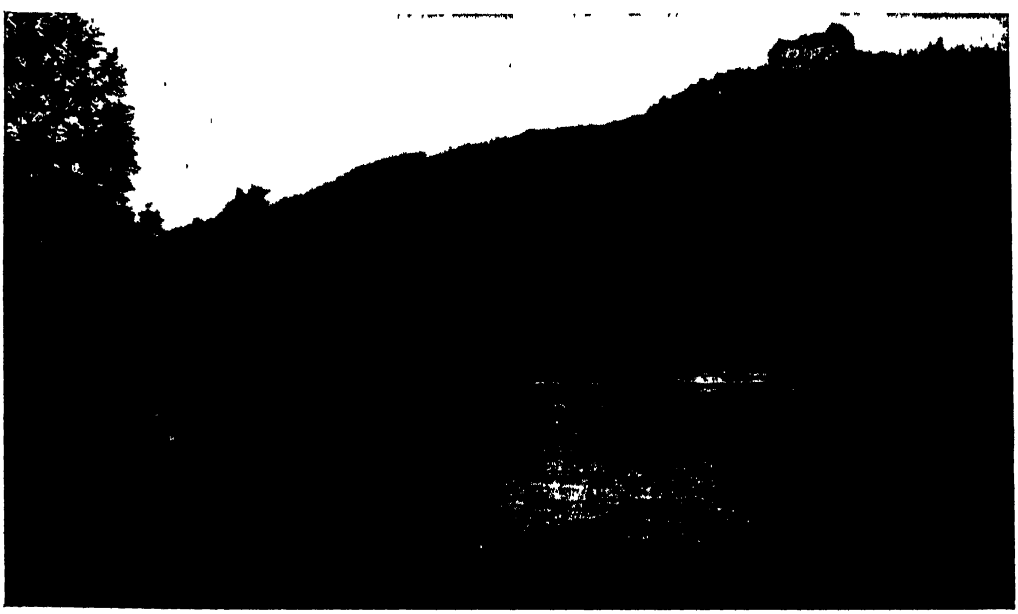
Indeed, it would almost seem as if the mountain scenery affected the character of the people who inhabit mountainous districts, for mountaineers are notably brave, vigorous and independent. Probably, however, the highland character is the result of struggle with an adverse and stringent environment, rather than the result of intercourse with the grand and sublime in nature. Even the tourist realizes that the mountains are not merely to be admired, but also to be conquered. Difficulties and dangers must always attract the combative spirit of man; and though the conquest of a Mont Blanc or a Matterhorn may to some seem to be waste of energy, the exercise of strength, courage and patience involved in mountaineering braces and invigorates the sinews of the mind as well as the muscles of the body.

But, in the first place, what is a mountain? At what height does a mound become a mount? That is a question that each land must answer for itself, for it is largely a matter of comparison A small hill in a flat country, arising abruptly from the plain, may seem a veritable mountain to the dwellers on the plain.

THE MOUNTAIN OF HEAVEN — THE HIGHEST ELEVATION IN DENMARK

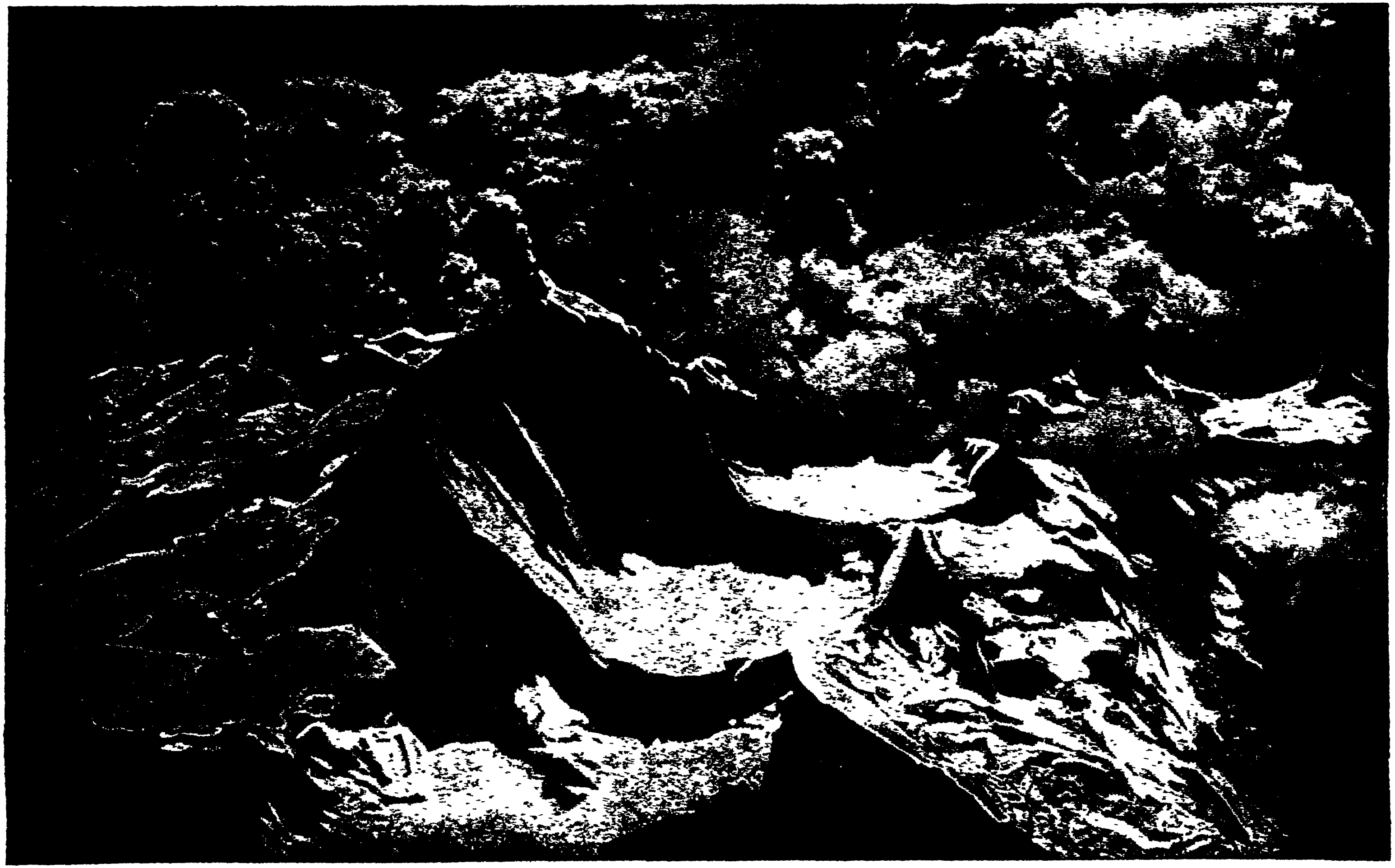
Thus, as Reclus points out, a hill only 780 feet high which rises from the level plains of Lower Pomerania impresses the inhabitants so much that they have named it the "Mountain of Hell", while a smaller hill in Denmark but 557 feet high is named by the cheerier Danes the "Mountain of Heaven". In a general way, however, to deserve the name mountains must be some thousands of feet in height.

As a rule, the higher mountains of the world are congregated into groups, and are arranged linearly in ranges and chains. Thus we have the Rockies, the Pacific ranges, the Alps, the Apennines, the Andes, the Himalayas. But, in some instances, a high mountain stands in splendid isolation, like Roraima 8740 feet in Venezuela, and, 50 miles away, Mount Kukenaam (over 8500 feet). These isolated hills are



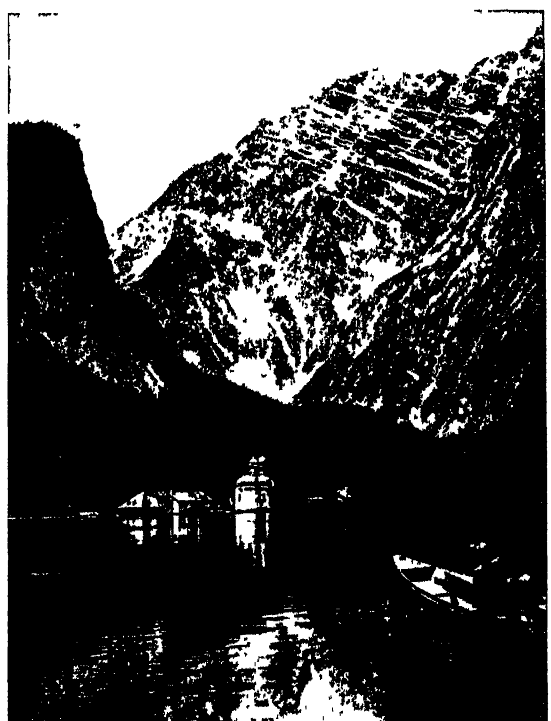
THE MOUNTAIN OF HELL, IN THE FLAT COUNTRY OF LOWER POMERANIA, PRUSSIA

INTERACTION OF EARTH AND ATMOSPHERE IN THE THIN, COLD AIR OF THE LOFTIER ALPS



THE JUNGFRAU, AND OTHER PEAKS OF THE BERNESE OBERLAND RANGE, AS SEEN AND PHOTOGRAPHED FROM A BALLOON

colossal earth pillars which resisted the eroding waters that cut down the surrounding country. They are called "monadnocks" in this country, after the mountain of that name in New Hampshire. Mount Wachusett in Massachusetts is of similar formation Other isolated mountains, such as Vesuvius, Fujiyama and Stromboli, are of volcanic origin. But these solitary peaks are the exceptions, and most mountains are congregated into mighty communities. When we examine the great mountain communities we notice at once that their arrangement is markedly linear. The Alps run in ranks east and west, the Himalayas and the Pyrenees also run east and west, while the Andes, Apennines and Rockies run north and south


© Underwood & Underwood, N Y
THE GREAT WATZMANN, IN BAVARIA

The ranks, of course, are manifold; and though most of the valleys correspond in direction with the linear extension of the mountains, there are numerous passes and transverse valleys that interrupt the linear continuity of the ranges In the Alps there are many hundreds of distinct valleys; in the Canton Grisons alone there are about five hundred, forming a regular labyrinth.

Let us look for a moment at the height and disposition of some of the great mountain ranges. The Pyrenees run between France and Spain, forming a great mountainous barrier between the two countries From a principal double rampart of mountains running east and west, transverse mountain chains running north and south are given off, and these transverse chains give off secondary chains at right angles to themselves, and more or less parallel to the principal rampart, the whole mountain system accordingly somewhat resembling the frond of a fern Very few, if any, of the great mountain ranges of the world can be analyzed into such a simple system. Most of the peaks of the Pyrenees are sharp and pointed, and the general effect is a serrated or dentate ridge. The average height of the peaks is almost 8000 feet, which is about 300 feet more than the average height of the Alps, but the Pyrenees are less striking than the Alps, because none of the peaks much outsoar the others.

The Alps are a much more labyrinthine and complicated series of mountains than the Pyrenees. Though the general trend of the range is east and west, its diversified branches are very numerous, and it can be divided into many more or less distinct systems, each with characteristics of its own. The central mass is the St Gothard group, from which all the principal chains radiate, but the most magnificent group is the mighty rampart of Monte Rosa, whose peaks all exceed 13,000 feet, Monte Rosa itself reaching 15,217 feet. Mont Blanc, the highest mountain of Europe, is 15,781 feet high, or rather was that height until the recent avalanche brought down a small portion of its pinnacle, but the average height of the mountains of its group is only 12,657 feet. Though the average height of the Alps is not so great as that of the Pyrenees, yet they are a much more striking system of mountains, because of the number of mountain giants, such as Mont Blanc, the Jungfrau, the Matterhorn and Monte Rosa, which they contain.

THE MONT BLANC RANGE, SEEN FROM ITALY

A view of the "monarch of mountains" taken from the Combin de Corbassière. In the middle distance is a fine bergschrund, where the snow-bed parts from the rocks of the Pointe de Combin.

The Himalaya range is the most southern of a triple rampart of mountains running east and west across Asia, to the north of India. The most northerly range of the triple rampart is known as the Kuen-Len, and the middle range as Karakoram. All three ranges are set on the plateau of Pamir, which is not unjustly called the "Roof of the World", and extend for a distance of 2000 miles, with a breadth in places of 620 miles. The height of these three great ranges is tremendous The peaks of the Karakoram have the greatest mean height; next come those of the Himalaya, and lastly those of the Kuen-Len. In the Himalaya range there are hundreds of peaks higher than Mont Blanc; while Mount Everest (29,002 feet) is almost twice the height of that king of European mountains. Mount Everest is, of course, the highest known mountain in the world, but Mount Godwin-Austen in the Karakoram, which is 28,271 feet high, and Kunchinjinga, 28,146 feet high, run it very close, while Dhawalagiri, 26,826 feet high, is quite a worthy rival. No other peaks in any other ranges can compete with giants like these; even the highest peak of the Andes is quite out-topped Mountains over five miles high are not to be found in any other part of the globe. From this gigantic rampart range flow the Indus and Brahmaputra, and between the Himalaya and the Kuen-Len is the plateau of Tibet, which is 13,000 feet above sea level, and measures 2000 miles from east to west, and 1700 miles from south to north. Though the Himalaya mountains are grander than the mountains of Switzerland, the scenery is not so picturesque and varied. "In all its grandeur, the Himalaya is uniform; its peaks are loftier, its snows more extensive, its forests deeper, but there are fewer cascades and lakes; there are no pleasant lawns and scattered groves, and we fail to notice the picturesque chalets nestling down in the glens, or hanging over the brink of the precipices." Owing to the height of the mountains and their situation in a warm climate, every climate is represented as we ascend the range. First we have a tropical climate with tropical flora and fauna, then a temperate climate with its flora and fauna, and finally we reach an arctic climate with perpetual snow.

THE PYRENEES, SHOWING THE TOWN OF LES EAUX BONNES AT THEIR BASE

NATURE MIRRORS WASHINGTON'S LOFTY PEAK

Photo Eugene J. Hall

MOUNT RAINIER (14,363 FEET) AND MIRROR LAKE

Since these great ranges run east and west, they put a great barrier between north and south; and since neither north nor south winds can pass the barrier, there is a marked difference in the climates to the north and south of the range Were the mountains removed, India would be cooler and northern Asia warmer On the other hand, it must not be forgotten that winds pouring downwards from the snowy peaks must, to some extent, mitigate the heat of the plains of northern India We shall deal later with descending mountain winds.

In North America we have the Rocky Mountains or the Cordilleran system, forming the major axis of the elevated lands of the western part, extending from Alaska to South America and separated from the Andes by a very low pass in Panama. The ranges near the Pacific are the Cascade and Sierra Nevada in the United States, and the Sierra Madre in Mexico and Central America. West of the Sierra Nevada in California is the Coast Range. The Coast, Cascade and Sierra Nevada ranges are really separate mountain systems though popularly said to belong to the Rocky Mountain system. The eastern chains of this system in the United States are the Rocky Mountains proper. In Colorado alone in this system there are about 40 peaks over 14,000 feet high, the highest in the Sangre de Cristo range being Blanca Peak, 14,463 feet The highest peaks of the general system are found in the Cascade range, Mount McKinley, 20,000 feet, Mount Logan 19,500 feet and Mount St. Elias 18,101 feet The Sierra Madre range boasts of two high volcanic peaks, Orizaba (18,300 feet) and Popocatepetl (17,887 feet). The great mountain system of the eastern United States is the Appalachian, running from northern Alabama into New York and probably embracing the New England system. It includes the Alleghanies, the Blue Ridge, the Cumberland, the Black, White and Green Mountains and the Catskills. This system is fairly long but narrow, at no point much over 100 miles wide. There are no very great elevations in the Appalachians, the highest peak being Mount Mitchell in the Black Mountains, North Carolina (6711 feet).

Photo B M DeCou, © Ewing Galloway, N. Y.

MOUNT SHASTA (14,380 FEET), A PEAK OF THE SIERRA NEVADA IN CALIFORNIA

In South America we have the magnificent range of the Andes, the longest and most continuous mountain system in the world. It runs north and south near the Pacific coast for a distance of 4500 miles. Though the average height of the peaks is considerably less than that of the peaks of the Himalayas and Karakorams, and though it contains none that can rival Mount Everest, yet it is the second highest range in the world. Its highest peak, Aconcagua, towers 23,000 feet above sea level, and it includes at least thirteen peaks over 19,000 feet. The height of the range, too, is remarkably consistent. Most of its passes are 14,000 feet high, and the lowest pass in a stretch of 4000 miles is 11,400 feet. The range divides South America very unevenly, its distance from the Pacific being 30 to 150 miles, while in places it is 3000 miles from the Atlantic. North of Aconcagua the range is double, and at one place the double chain incloses a plateau as large as the entire state of Maine. South of Aconcagua the range consists of a single rugged ridge which gradually dwindles as it runs southwards.

In northern Africa there is an extensive mountain system, starting near Cape Nun on the Atlantic and ending near the Mediterranean coast. The highest peaks of this system are Jebel Ayashi, 14,000 feet, and Tamjurt, 14,500 feet Most of the lofty mountains in Africa are volcanic Volcanic, for instance, are the Cameroons (13,760 feet), Kenia (18,370 feet), Kilimanjaro (19,300 feet). Yet, strangely enough, despite its few mountain chains, the African continent has an average height of 1640 feet — equal to the average height of Asia, with its Himalayas and Karakorams.

THE PASS IN THE ANDES IN TUNGURAGUA, ECUADOR, SHOWING THE SOURCE OF THE AMAZON

Having thus glanced at the great mountain chains, let us look for a moment at the uses of mountains. The mountains play a varied and important part in the economy of nature. Firstly and chiefly they focus the mechanical energy of the water lifted into the sky by the heat-energy of the sun

A PEAK IN THE CANADIAN ROCKIES

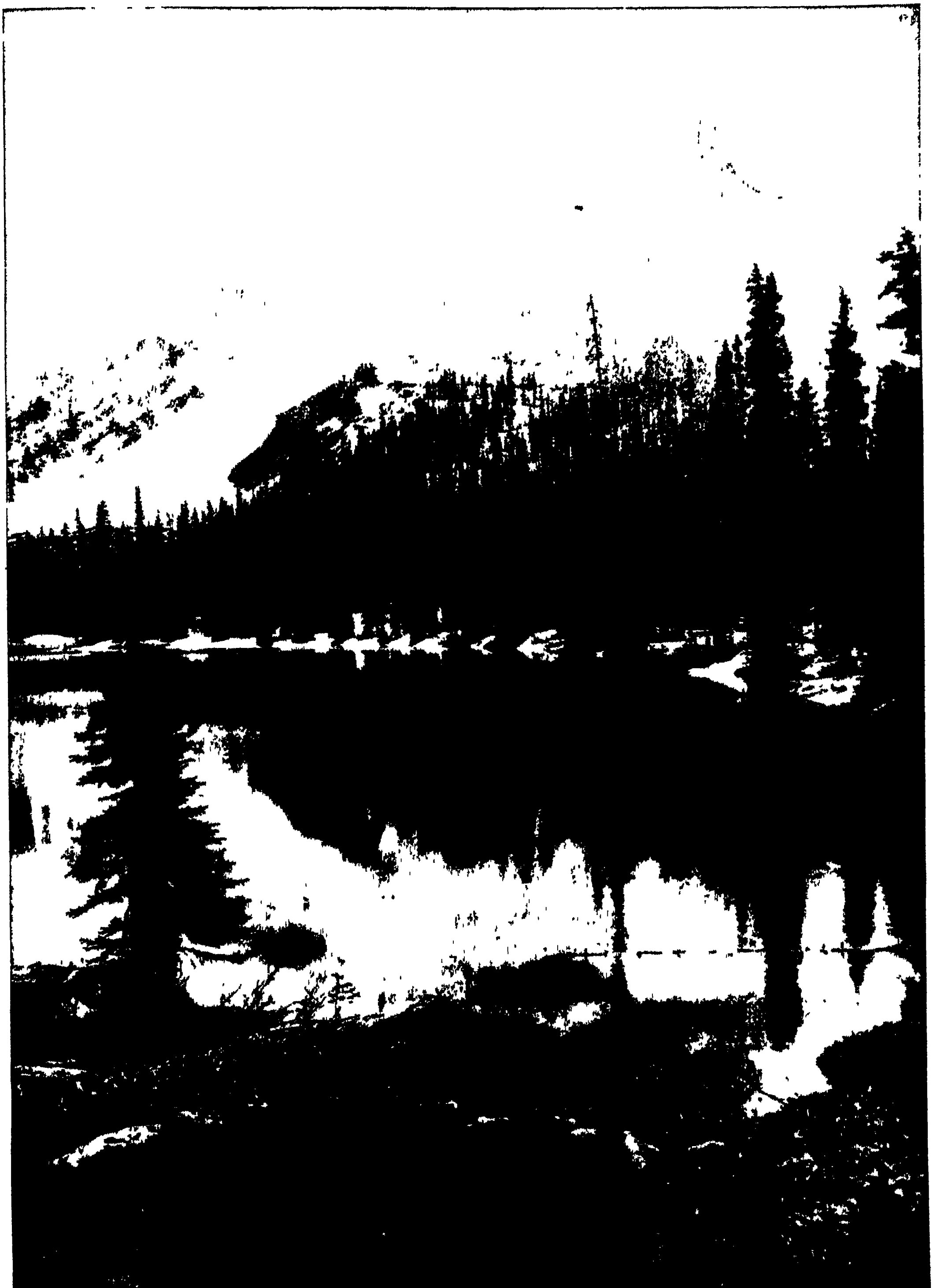
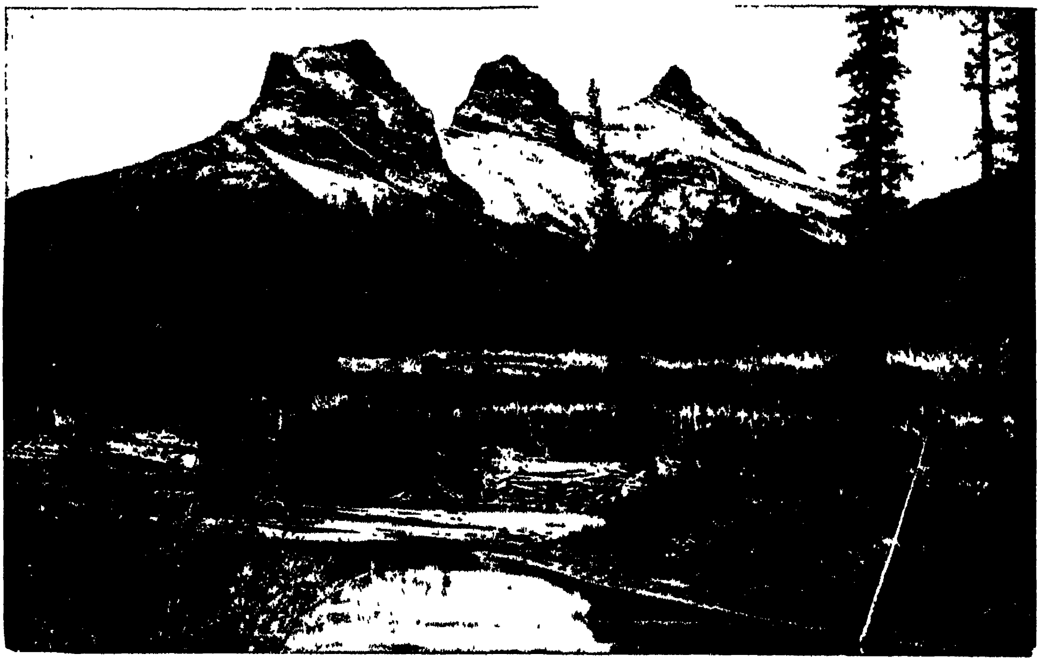


Photo B. M. DeCou. Courtesy Canadian Pacific Railway

MOUNT WAPTA AND SUMMIT LAKE

Now so far as the sun is concerned, the water-vapor would be spread uniformly through the atmosphere over the earth in a more or less indiscriminate way Were the earth flat, the rain would be much more equally distributed; there would not be 500 inches at Cherrapunji and 3 inches at Leh, in India, but about the same rainfall in both places; and most of the variations that at present exist in the geographical distribution of rain would be abolished. Where the hills and seas now are, the rainfall would be less, where the plains now are, the rainfall would be more Further, a great part of the land surface would be condensed as rain; in the second place, such a wind blowing against the base of any mountain is necessarily deflected upwards into the rarer atmosphere There it expands, and since expansion means cooling, the air is cooled, and deposits its load of moisture as rain. Not only does the cold mountain cool the air, then, but by directing its course upwards and compelling its expansion it forces the air to cool itself. The tremendous rainfall at Cherrapunji is due not only to the contact of the warm, moist monsoon with the cooler hill-tops, but also to the fact that the monsoon is forced upwards by the Khasi Hills.



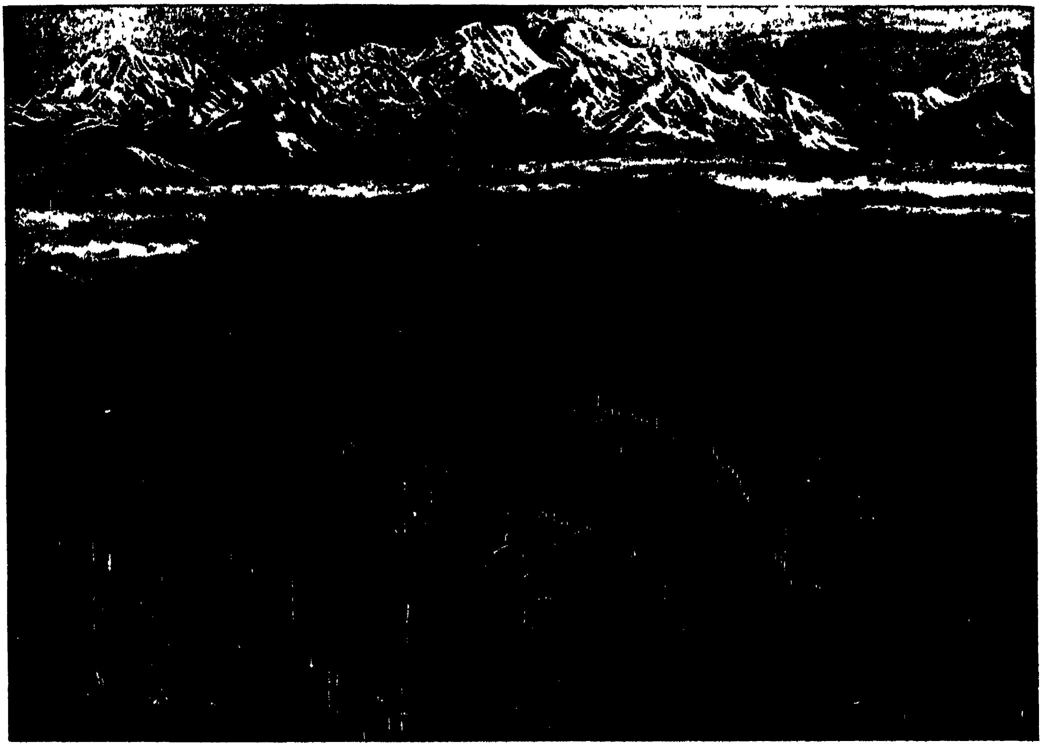
IN THE CANADIAN ROCKIES — THE THREE SISTERS OF CANMORE

verted into marshland and bog-land, for owing to lack of declivity drainage would be bad. It is the mountains that focus the rainfall; it is the mountains that concentrate it into certain downhill channels, and thus give it a maximum of mechanical power. Rain from the sky cannot turn a mill-wheel, but concentrated in a mountain torrent it can light a city, or grind corn, or husk cotton-seeds, or synthesize nitrates.

As we have already indicated, mountains gather and give rain in two ways. In the first place, any warm, moist wind blowing against a cold mountain summit is con-

Almost all the rainy places of the world are among the mountains, and most of the arid places of the earth are flat plains. The importance of this concentration and differentiation of rainfall is evident at once from a climatic, an agricultural, and a commercial standpoint. Did nature not make rivers for us, we should have, like the fabled Martians, to make canals, or construct colossal systems of aqueducts. We must have our water supply mobile for many reasons, and, if it is to be a source of power, we must have it concentrated in rivers and waterfalls.

It is difficult to realize the amount of energy a mountain can gather simply by collecting rain. The amount of sun-heat required to evaporate sufficient water to cover one square mile to the depth of one inch is equal to the amount of heat produced by the combustion of five thousand tons of coal. The equivalent, again, in mechanical energy of this amount of heat would be sufficient to raise ten million tons to the height of one mile. It is immense solar energy of this sort that mountains seize and concentrate and utilize — energy that otherwise would be dissipated and, in great measure, wasted.



A DISTANT VIEW OF THE HIMALAYAS, SHOWING MOUNT KUNCHINJINGA

But mountains do more than seize and concentrate this hydraulic equivalent of solar energy; they also sometimes hoard and bank it. All these white summits of the Alps, the Himalayas and the Andes represent an enormous reserve capital of mechanical and chemical power. In winter the balance increases; in summer it diminishes, and the general result is a banking of energy at certain points, with a redistribution of it at certain times, both in the form of rivers of water and in the form of rivers of ice, but through both forms to the general advantage of the lowland world.

Were it not for the Alps, the Po, the Rhone, the Rhine and the Danube would be mere brooks in summer. "But for those barren fields of ice," writes Bonney, "high up among the silent crags (of the Alps), the seeming home of winter and death, these great arteries of life would every summer dwindle down to paltry streams, feebly wandering over stone-strewn beds. Stand, for example, on some mountain-spur and look down on the Lombardy plain, all one rich carpet of wheat and maize, of rice and vine; the life of these myriad threads of green and gold is fed from these icy peaks, which stand out against the northern sky in such strange and solemn contrast. As it is with the Po, so is it with the Rhine and the Rhone, both of which issue from the Alps as broad, swelling streams; so too with the Danube, which, although it does not rise in the Alps, yet receives from the Inn and the Drave almost all the drainage of the eastern districts."

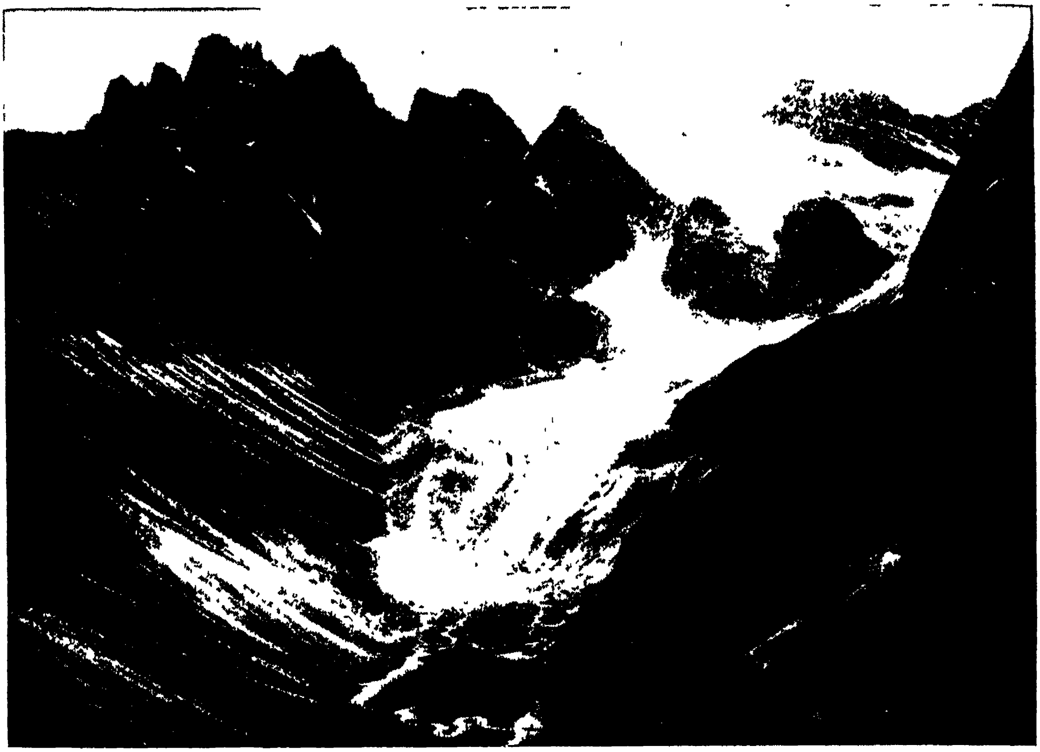


Photo Wide World

BONNINGTON PEAK AND GLACIER, JASPER NATIONAL PARK, ALBERTA

But mountains do not always keep their reserve of water in cold storage, they also hoard it in mountain marshes, peat-beds and bogs. The amount of water so kept in reserve, and economically and slowly expended by a process of gradual drainage, may be very great. Some flat mountains in times of rain are simply colossal sponges.

Mountains, then, as makers and conservators of water-force, play a most important part in nature, they are in a sense at once the mainspring and the controlling lever of the greater part of the water-energy of the world.

But they can make rivers only at the expense of their own substance. Much of the great energy they render available goes to the destruction of themselves. Every brook brawling down the mountain takes part of the mountain with it, no matter how hard and durable the rock may be.

Yet this destruction of the mountain is the salvation of the world as the habitation of living things; the debris of the rocks is the food of all the forests and gardens and meadows of the world. The rivers and glaciers wear down the mountains to make soil for the roses and cabbages. The most fertile lands in the world — the delta of the Nile, the Imperial Valley of California — are made of the wear and tear of mountains brought down by rivers, great and small.

Mountains, then, concentrate and apportion rain and make soil. Further, they promote the circulation of air, through the difference of temperatures at their bases and summits, and the rapid changes of temperature to which their peaks are subject During a sunny day the top of a mountain is more heated than the plain below, and hence during the day there is an ascending current of cooler air from the plain to the mountains. At night, again, the hilltop cools more rapidly than the plain, and so there is a descending current of cool air from hilltop to plain. The mistral so much dreaded on the Riviera is a torrent of cold air pouring down from the summits of the Cevennes and Maritime Alps. The bora of the Adriatic, and the tramontana negra or black norther of

PIKES PEAK, WITH A FRESH MANTLE OF SNOW

Greece, the "Majorcan carpenter", the black bise of Algeria, have similar origin. In the Himalayas the updraught is very marked, and blows from 9 A M to 9 P M. It is rather interesting to notice how even unscientific men have discovered this regular alternation. The hunter will build his fire below his tent at night, and above his tent in the morning, so that the smoke of the fire may blow away from the tent; and in certain valleys the inhabitants build their huts and houses on raised ground, to be above the river of cold air which flows down the mountains on winter nights.

All these functions, then, in the economy of nature mountains play; and in addition they form natural barriers between nations, and between flora and fauna — barriers which have great historical and biological, as well as panoramic, significance.

LONGS PEAK AND MOUNT MEEKER, MOUNTAIN NATIONAL PARK

DEADLY WEAPONS OF MAN'S INSECT FOE

THE HEAD AND MOUTH PARTS OF THE FEMALE MALARIA MOSQUITO, ANOPHELES

The mouth-parts are here shown separated, but in their natural state they are all perfectly arranged in the proboscis like a set of surgical instruments. The upper lip is seen on the left and the lower on the extreme right: between these are the thread-like lancets and two hairy palps. The whole group, when closed, constitute the proboscis—highly magnified. In the top right-hand corner of this picture is shown a tip of one of the lancets magnified in area 25,000 times; this photograph showing the barbs.

These photographs are by Mr. J. J. Ward

MAN AND THE MOSQUITO

The Story of the War Waged by Men of Science of All Nations Against Malaria

DEFEATING AN ALLY OF BARBARISM

WE have already seen that the powers of life have manifested themselves, above all, in the insects, with their instincts, at the head of the invertebrate world, and in man, with his instincts and his intelligence, at the head of the vertebrate world No actual "struggle for life", of any importance, exists between man and the highest insects, the social hymenoptera, such as the bees. But among other insects we now begin to find the chief effective enemies of man, apart from such microbes as that of tuberculosis Further, we find that the insects which man has most to fear are not deadly in themselves, though undoubtedly parasitic upon his blood, but injure him, as it were, accidentally, because of certain minute parasites which make hosts for themselves, both of man and of the insects. Thus the "struggle for life" and the "balance of nature" take on most complicated forms, which we require to unravel, first for their inherent interest; and second, because our life and death, health and disease, success and failure (as in trying to sever continents), are so intimately concerned.

Here, again, Louis Pasteur was the pioneer. In the 'seventies of the nineteenth century he established in Paris the school of thought and practice which led the way to conquests of which even he could scarcely dream; and just as Sir Frederick Treves has said that the late Lord Lister, the greatest of Pasteur's disciples, won for Japan her war with Russia, as we shall see, so it may be said that Louis Pasteur dug the Panama Canal. Let us trace the sequence of events.

It was the German pupil of Pasteur, Robert Koch, who, as we have seen, discovered the microbic parasite of tuberculosis, a discovery from which is now surely proceeding the extermination of that disease. All parts of the civilized world sent their representatives to the Pasteur Institute in those days, but France herself was not lacking. Thus Charles Louis Alphonse Laveran, a French army surgeon—as he then was—took the opportunities which were before him in North Africa, and began to hunt the blood of malaria patients, in the hope of finding some causal parasite, such as his teacher was finding in other diseases

Laveran's work was not unrewarded, and he duly found a parasite which was invariably present in all cases of malaria. The Germans had previously noticed that a certain kind of pigment was deposited in the liver and spleen of persons dying of malaria. When Laveran in 1880 discovered a parasite in the red blood-cells he noted that this same pigment was formed in the parasite. This at once cast suspicion upon the parasite as being the cause of the malaria and the pigment. Golgi, an Italian, verified Laveran's discovery, and in 1885 this Italian showed that the malarial chill, fever and sweat occurred at the time when the parasite "sporulated". When it was noted that malaria and swampy areas existed together, the mosquito's connection with the disease was suspected, but it was not until 1895 that the mosquito was definitely found to be the carrier of the disease.

A French physician's discovery of the hæmatozoon of malaria

Laveran's Algerian work, with his result, was published in 1880 in his "*La Paludisme*" Paludism (that is, marsh-ism) was, and is, indeed, the technical name for malaria, indicating its almost invariable origin in connection with marshes. But this book gave us a new conception of the disease, and of the appropriateness of its names. The word "mal'aria" is obviously nothing but Italian for "bad air" Now, marshes, especially at night, beget a "dangerous night-air", or "miasm", which may seem to be the cause of the illness which often attacks dwellers on marshes, just as "sewer gas" was thought to be the cause of puerperal fever, typhus and typhoid But Laveran showed us that, in fact, the disease "ague", malaria so-called, or paludism so-called, is not due to bad air, is not due to marshes, but is due to a living parasite which multiplies in enormous numbers in the blood of the patient, destroys his red blood-cells, produces poisons, and so causes the well-known symptoms of the disease.

The parasite, illustrated on page 3326, is not a plant, like the bacilli of tuberculosis and so many other diseases, but a minute animal. As it inhabits the blood of man, it may be spoken of as a hæmatozoön, or blood-animal. It is one of the great group of animal forms which the zoölogists call the "protozoa", or "first or simplest animals", the humblest group that they know

The life-cycle within man of the two varieties of malarial parasite

It occurs in the blood of man in various shapes and states, some of which are specially characteristic of one type of malaria, and others of other types. For the acute attacks in this disease occur at different intervals in different cases, so that we used to speak of "quotidian fever", "tertian fever", "quartan fever", according to the number of days elapsing between the febrile attacks.

We now know that these differences depend upon the particular variety of parasite with which the patient has been infected, and that in certain types of the disease the symptoms are due to a double infection with two varieties of the parasite, each going through its own life-cycle at its own rate. The generations follow one another with extreme and, for the unfortunate host, disastrous rapidity; and the birth of each new generation of young forms in the blood of the patient appears to coincide with the production of certain poisonous substances, which show their power by the production of a fresh attack of shivering and fever for the unhappy victim

It has further been found — to complete our initial account of the parasite itself — that this humble organism, contrary to all expectation and previous zoological experience, is sexual, or, rather, that its life-history comprises a sexual stage Two forms, male and female, each consisting of only a single cell, can be identified, and, as we shall see, this occurrence of a sexual phase in a complete life-cycle of the parasite, which cannot be completed in the blood of man, renders an intermediate host necessary for the continuation of this race of minute organisms.

Parasite that causes the greatest amount of illness and the drug that checks it

The malaria parasite has a wide distribution upon our planet The disease it causes is the most common, though tuberculosis is the most deadly, to which man is subject. Undoubtedly this parasite causes more illness than any other. If we include certain of the lower animals within our purview — as is well worth while, we shall discover — we find that closely allied forms of parasites, cousins, so to speak, of our own, inhabit the blood of other creatures, causing similar symptoms in them Conspicuous in this relation is the avian malaria which attacks various species of birds, and which helped us to discover what is so essential for any success against malaria.

Perhaps one should not say "any success", for that is to do less than justice to the wonderful drug quinine The bark of the cinchona, often called "Jesuits'

bark", in honor of those who first popularized its use, contains various peculiar alkaloids, and, above all, the one called quinine, which can enter the blood, when a preparation of the bark, or of the alkaloids themselves, is swallowed, and can there kill the malaria parasite, in the great majority of cases That drug has saved untold myriads of lives, and has very valuable uses against malaria even today. But on all grounds it is better not to have the parasite in one's blood at all.

How, then, does the parasite get there, and what part do the marshes play in "paludism", and the air which comes from them at night in "malaria"? The association is unmistakable, and has been recognized from the most ancient times. A precise explanation of it would surely give us the means of abolishing malaria wherever we chose to do so

First records of the truth concerning the origin of malaria

A few wise men had "guessed" the truth, long before the parasite was known. In an Eastern work on medicine, fourteen hundred years old, it was stated that malaria is carried by flies or mosquitoes Early in the nineteenth century an American doctor blamed mosquitoes for both malaria and yellow fever. But the Frenchman Dr. Beauperthuy is the real pioneer. In 1853 he sent an essentially complete account of the truth to the French Academy of Sciences, asserting that mosquitoes inoculate man with malaria and yellow fever; that these diseases are not contagious, and, as for marshes, that "marshes do not communicate to the atmosphere anything more than humidity, and the small amount of hydrogen they give off does not cause in man the slightest indisposition in equatorial and inter-tropical regions renowned for their unhealthiness. Nor is it the putrescence of the water that makes it unhealthy, but the presence of mosquitoes." Thus the French doctor's guess was forty-two years ahead of its proof, and never has a scientific proof more completely verified the guesses of a man of patience and genius than in this instance.

Ignoring other steps in our knowledge, we come to the notable suggestion and demonstration, made by the English physician Patrick Manson, in the early 'eighties, that a certain worm disease, called filariasis, is transmitted by the bite of the female mosquito, since it was found that the mosquito is the "intermediate host" of the parasitic worm in question Briefly, it suffices to say that many creatures, such as the filaria (and now, as we know, the malaria parasite), pass the cycle of their lives in two stages — the first in an animal of one species, and the second in an animal of another

Manson's study of the worm that is carried to man by the mosquito

Thus, the trichina worm lives in the pig and in man, as Virchow first showed in Germany; and every succeeding step in our knowledge has added to the importance of these peculiar life-cycles, in the case of many parasites — above all, where one of the hosts is man.

We may feel little interest in filariasis, but the worm which causes this disease is a curse of the tropics, infecting in some parts of China, for instance, half of the population. Early in the 'seventies, Manson, who was then in Formosa, tried to puzzle out the facts. Another observer had traced the disease to the tiny worm, the filaria Manson went back to China, and continued his study and speculation What could possibly convey this worm to the blood? Might it not be something capable of piercing the skin, taking some blood, containing the worm, and then transferring it to another person? The only likely or imaginable agent was the mosquito. So he made a test, getting a Chinaman who had filariæ in his blood to be bitten by mosquitoes, and then examining them. The filariæ were found in the stomachs of the mosquitoes, and not dead, but alive and active.

Finally, Manson traced certain changes and peregrinations of the filariæ, until they reached the sheath of the mosquito's proboscis, whence they were injected into the blood of a fresh patient. This shows us finally that "man harboring the para-

site is the reservoir, the mosquito is the carrier of the parasite. . . . The parasite passes part of its existence in man, and part in the mosquito; both man and the mosquito are necessary for the complete development of the parasite. Therefore, if the mosquito is destroyed, the life-cycle of the parasite is destroyed, and the disease must of necessity cease."

Ross's discovery of how mosquitoes convey malaria from man to man

In 1895 Major Ronald Ross discovered the parallel fact for malaria. "A water-breeding mosquito sucked, not decomposed vegetable or animal matter at the marsh, but the blood of a man suffering from malaria, in which there were parasites in abundance The parasites sucked in with the meal of blood underwent further development in the mosquito — *i e*, infected the mosquito; and then when the *infected* mosquito, which had now become the *carrier*, bit man, it *infected* him" Simple, is it not? But this true theory of such diseases built the Panama Canal and is changing the face and destiny of the world

After discussion with Manson, Major Ross went back to India, and began hunting for Laveran's parasite in the bodies of mosquitoes Nothing came of it But at Secunderabad he noticed a special kind of mosquito, not the ordinary, too familiar *Culex*, and it occurred to him that he must systematically look for the parasite in every kind of mosquito that ever bit man Working eight hours a day at his microscope, under cruelly difficult conditions of heat and persecution by flies, he persisted, and was finally rewarded.

Ross's researches respecting the presence of malarial parasites in mosquitoes

"On August 20th I had two remaining insects, both living. [They were insects which were known to have bitten malarial patients.] Both had been fed on the 16th. I had much work to do with other mosquitoes, and was not able to attend to these until late in the afternoon, when my sight had become very fatigued. The seventh dapple-winged mosquito was then successfully dissected. Every cell was searched, and to my intense disappointment nothing whatever was found until I came to the insect's stomach. Here, however, just as I was about to abandon the examination, I saw a very delicate circular cell, apparently lying among the ordinary cells of the organ, and scarcely distinguishable from them Almost instinctively I felt that here was something new. On looking further, another and another similar object presented itself I now focused the lens carefully on one of these, and found that it contained a few minute granules of some black substance, exactly like the pigment of the parasite of malaria I counted altogether twelve of these cells in the insect, but was so tired with work, and had been so often disappointed before, that I did not at the moment recognize the value of the observation. After mounting the preparation, I went home and slept for nearly an hour. On waking, my first thought was that the problem was solved, and so it was."

Experiment with infected mosquitoes

He traced the development of the parasite within the mosquito, and by means of special staining he showed how the parasite produces spores, and traced their course. Here are his words. "The exact route of infection of this great disease, which annually slays its millions of human beings, and keeps whole continents in darkness, was revealed. These minute spores enter the salivary gland of the mosquito, and pass with its poisonous saliva directly into the blood of man. Never in our dreams had we imagined so wonderful a tale as this."

For this discovery, in especial, Ross received the Nobel prize for medicine some years later Meanwhile his work had been confirmed. In 1900, mosquitoes were conveyed from the Campagna, in Italy, having first sucked up a meal of blood from a malaria patient. Under the direction of Manson, two gentlemen, one of them his own son, neither of whom having ever been out of England, offered themselves to be bitten by these mosquitoes.

Young Manson contracted malaria, and parasites of the same type as in the Italian case were found in his blood. He was "cured" with quinine, but had a recurrence about a year later — some parasites having been in hiding in his body meanwhile

This experiment demonstrated that a person could contract malaria where epidemic malaria did not exist, provided that he was bitten by *infected mosquitoes*. Ross had, therefore, worked out the whole story. The mosquito was the carrier of malaria *from man to man*. Malaria had no connection with miasms. The reason why malaria was associated with marshes and water was simply that mosquitoes bred there.

Photo Elliott & Fry

MAJOR RONALD ROSS

Until this discovery man's sole weapon against malaria was quinine This drug usually cures, and it may be used so as to prevent, being taken regularly in comparatively small doses, so as to keep a certain proportion in the person's blood, against the arrival of any possible parasites. This "quinine prophylaxis" — *i.e.*, prevention — is still a useful weapon, but a more evident one is to destroy the mosquito. If the problem were to exterminate all mosquitoes, it would be a well-nigh impracticable one, but Ross was very soon able to show why he had for so long not met with success. He had spent nearly all his time upon kinds of mosquitoes in which the parasite cannot live. Many mosquitoes bite, but the only kinds which can become infected with the parasite producing malaria in man belong to a particular group, of which the general name is *Anopheles* or the Anophelinæ. To exterminate the anophelines is by no means impossible, if we set about it rightly. But the method is all-important; and it applies no less at our own doors than in the tropics.

A hundredth part of the labor will have a hundred times more effect if we proceed on sound biological lines If we want to increase the number of a species, such as our own, we must care for the young, the parents, the homes; if we want to reduce the number of a species, such as flies or mosquitoes, we must attack the young, the parents, the breeding-places. Special inquiry has been made into the habits of anophelines, and we know exactly what the problem is. The male anopheline matters not. His mouth parts are not fitted for piercing; he is exclusively a vegetarian The female alone concerns us, for she alone pierces the skin, and can harbor the parasite. She "breeds in small collections of water — those with a natural earth bottom, such as small pools and patches of water of all descriptions, margins of streams and lakes and odd receptacles coated with humus" — that is to say, with decomposing vegetable matter and soil.

In the first place, then, let mosquito-nets be used; let us dose ourselves with quinine when living in localities where malaria is prevalent; and let us avoid going out into the "dangerous night-air", for it is in that air that the female mosquito flies when she is hungry. But if we attack pools, by whatever means experience has shown to be appropriate in a given case, we shall reduce the number of mosquitoes indefinitely. If we do our

task well enough, all other precautions will be rendered superfluous And, since no useful method must be ignored, let us observe that the indigenous population of a malarial region harbors the parasite to an extraordinary extent — 80 to 90 per cent — without showing any particular symptoms. These "healthy reservoirs" become the source of infection for anophelines breeding in small collections of water in the neighborhood, and these infected anophelines soon bite any newcomer and infect him

A summary of the means of defense and offense against malaria

The lines of defense and offense against malaria can now be defined; and here they are:

1. Measures to avoid the human reservoirs —
   (*a*) By means of segregation,
   (*b*) By screening with nets those suffering from malaria.
2. Measures to avoid the anophelines —
   (*a*) By choice of suitable locality, when possible;
   (*b*) Screening houses (windows and verandas);
   (*c*) Sleeping under mosquito-nets.
3. Measures to exterminate the anophelines —
   (*a*) Use of the natural enemies of mosquitoes,
   (*b*) Use of mosquito-killers, such as sulphur and pyrethrum;
   (*c*) Use of larvicides, kerosene, crude oils of paraffin, etc.
   (*d*) By drainage and scavenging, to get rid of breeding-places;
   (*e*) Penalties for harboring larvæ or keeping stagnant water;
   (*f*) Education.

The substance of modern treatises on malaria prevention cannot be compressed into this chapter, but the foregoing comprise all the measures which, between them, or portions of which, have already abolished the disease in various parts of the world Here we need specially refer to only a few points of general scientific interest. The first has reference to the natural enemies of the mosquito, and here our Darwinian studies come to our aid We have seen what the "balance of nature" means, and Darwin has taught us how the numbers of species are kept down by the existence of other species. He has also taught us that the immature are by far the easiest victims.

Natural enemies of mosquitoes that should be cultivated

So here, doubtless, the adult mosquito has its enemies, such as birds, but it is the larvæ that perish most abundantly, and their great enemies are fish; or, to put it in another way, the natural food of many fish is the larval form of the mosquito Thus, in Barbados there are no anophelines and no malaria, though the other West Indian islands are plagued with the disease Yet Barbados abounds in swamps and ponds The inhabitants are protected by a tiny fish, so numerous as to be called "millions", a kind of "toy minnows", which live near the surface of the water, and whose staple diet is the larvæ of mosquitoes, if any there be Such fish can be imported into other waters containing mosquito larvæ

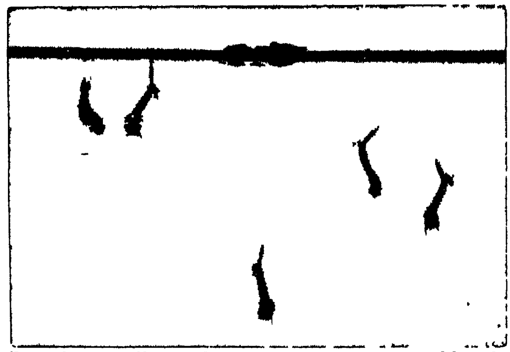
The use of kerosene and other oils is also advocated, for oil forms a film on water, and prevents the larvæ from reaching the surface to breathe. In certain cases this is a useful method, but, as experience has demonstrated repeatedly, the proper method is to drain puddles, swamps and pools, so that they shall not abound in the very midst of towns as still they too often do Now let us try to summarize results as hitherto attained. In his "Researches on Malaria", Ross eloquently states the facts of the past. Malaria, he says, "strikes down not only the indigenous barbaric population, but, with still greater certainty, the pioneers of civilization — the planter, the trader, the missionary and the soldier. It is therefore the principal and gigantic ally of barbarism. No wild deserts, no savage races, no geographical difficulties, have proved so inimical to civilization as this disease. We may also say that it has withheld an entire continent from humanity — the immense

and fertile tracts of Africa; what we call the Dark Continent should be called the Malarious Continent; and for centuries the successive waves of civilization which have flooded and fertilized Europe and America have broken themselves in vain upon its deadly shores" The difference between the races of men living in Africa and in Europe today is probably due to the malaria-bearing mosquito alone.

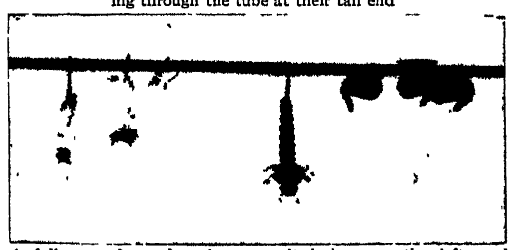
In Italy the campaign against malaria was started in 1902, and in seven years reduced the annual mortality from about 16,000 to about 4000. In the plain of Marathon, in Greece, thanks to Ross, in two years the proportion of all sickness due to malaria fell from 90 to 2 per cent. And Ross significantly adds, for those who mistake the true spheres of international competition, that "the best kind of international race is that in which nations compete to benefit humanity" Who is trying to win in this kind of "Marathon race"? The Suez Canal Company was cursed with malaria at Ismailia. Italian workmen employed in the construction of the canal probably came as reservoirs of the parasite, and the anophelines did the rest. In 1886 it was computed that every inhabitant suffered from the disease. As early as 1901 the company sought the help of Ross and every breeding-place of the anophelines was abolished. Since 1905 *no case of malaria* has been reported in Ismailia; and the company hope to make a sea-bathing resort for the inhabitants of Cairo out of what was a mosquito-plagued town and a nest of malaria.

At Port Said, Dr. E. H. Ross, brother of Major Ronald Ross, started successful work in 1906. At Khartoum, Dr. Andrew Balfour began his task in 1904. "He organized anti-mosquito brigades to examine all breeding-places, water receptacles and pools, and then organized measures for drainage, oiling, etc. As the result of five years' work, Khartoum is declared almost mosquito-free, and primary cases of malaria are exceedingly rare." Great success has been attained in Algeria, where the problem of the native Arabs, who act as "healthy reservoirs" of the disease, has to be met.

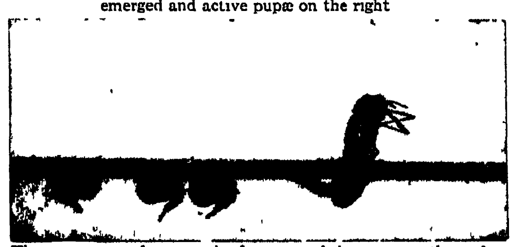
Sierra Leone, the "White Man's Grave", was the first place chosen by Ross for a practical test of his theory Magnificent success was attained The African Association reported that "1908 was the first year in the history of the company in which there had not been a death in the whole of our coast staff".



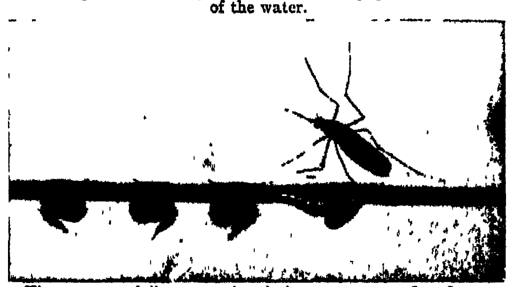
Egg rafts and half-grown larvæ of mosquitoes diving and breathing through the tube at their tail end



A full-grown larva breathing, moulted skins on the left, and emerged and active pupæ on the right



The emergence of a mosquito from one of the pupæ on the surface of the water.



The mosquito fully emerged and about to take its first flight.

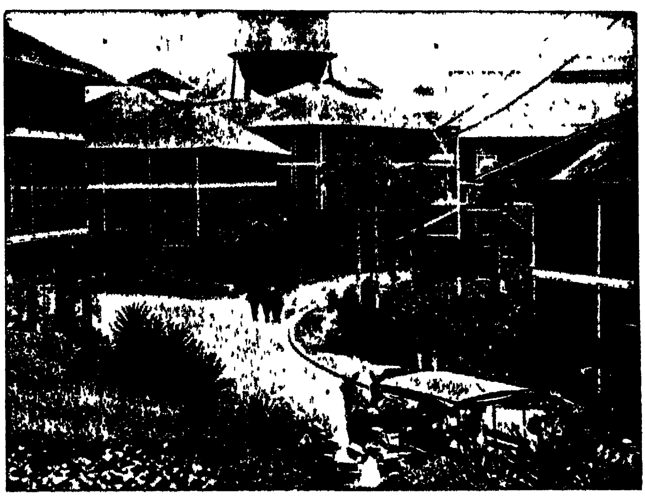
STAGNANT WATER THE NURTURE-GROUND OF MOSQUITOES

THE STAGNANT POOLS IN THE STREETS OF OLD PANAMA, WHERE THE MOSQUITOES USED TO BREED

ONE OF THE FINE NEW STREETS OF PANAMA FROM WHICH MOSQUITOES HAVE BEEN BANISHED

The French tried to build the Panama Canal, and retired, beaten by two kinds of mosquitoes, one spreading yellow fever, the other, malaria, after a loss of fifty thousand men. In 1904 the United States took over the Canal Zone, and the medical men who were assigned the task of clearing up this fever-infested zone set to work, with a staff of two thousand. In 1906 the deaths from malaria were 821; in 1908 they were 282, or 1 34 per thousand, and today yellow fever and malaria have been practically eliminated from the zone Systematic drainage was the method followed here, together with the use of kerosene in some places, and with the taking of quinine as very subsidiary

In Colon, Rio de Janeiro, Havana and Belize similar results have been obtained. The West Indies are now making good progress, with the usual quick and unmistakable results. The result of the Spanish-American War was most remarkable, not only in Cuba, as we shall later see in reference to yellow fever, but elsewhere Just as France failed at Panama because of ignorance — which was certainly no fault of hers, for the mosquito had not then been incriminated — so Spain failed to hold her colonies because of ignorance — in her case largely inexcusable. Ignorance of the laws of health destroyed the health and lives of 100,000 Spanish soldiers in Cuba in three years. The case was similar in the Philippines. Now the unequaled. Medical Department of the United States Army is in charge of the health of the Philippines, and everything is changed The death-rate among the troops in Porto Rico is practically the same as at home, and that of the civil population in Manila compares favorably with the rest of the world



THE MOSQUITO-PROOF QUARTERS OF THE ENGINEERS OF THE PANAMA CANAL

Nowhere in the world, perhaps, are the ravages of malaria worse than they are in India, where some five millions of deaths are recorded every year from "fever", and the vast bulk of these are none other than malaria. As for the military population, it was recorded in a typical year that, out of a total force of 305,927, there were admitted into hospitals 102,640 cases suffering from malaria. This is not a disease which suddenly and mercifully cuts off its victim, till then healthy, thus leaving room for another healthy man to succeed him On the contrary, it is a chronic, undermining, slow intoxication; and the net sum of its action within the body is to sap its victim of his energy. Above all, this disease attacks the power to work, the *economic efficiency*, of its victim. Where there are millions of deaths recorded annually, the total of sick is huge — probably seven or ten times as many. According to Dr. Howard an estimate of 3,000,000 cases of malaria per year in the United States would not be too high and the resultant annual financial loss from this disease alone is said to be not less than $100,000,000. If such be the conditions in the United States, where a large portion of the country is relatively free from malaria, what must be the conditions in Mexico, Central America and the tropical regions of South America, Africa and Asia, for in regions that are highly malarial at least one-third of the population suffer annually from this dread disease? The problem of malaria in any country is therefore not a matter of humanity only. It is one of national maintenance.

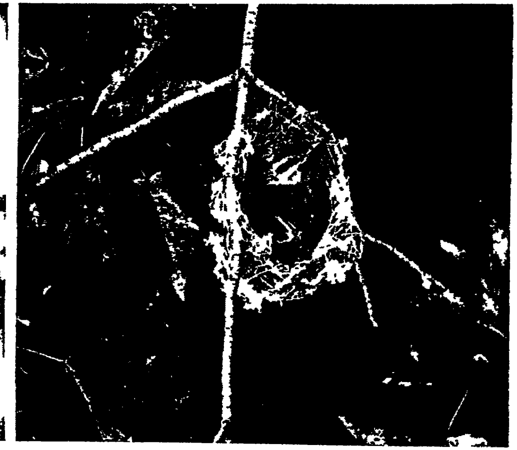
SEVERAL LITTLE GAD-ABOUTS AND A STAY-AT-HOME

BALTIMORE ORIOLE ABOVE ITS NEST

Winters in Central America and comes back the first of May, like other movers.

EARLY ROBIN OVERTAKEN BY LATE SNOW

The robins merely assemble for the winter in the southern part of their breeding range and start northwards early in the spring



A RED-EYED VIREO ON ITS NEST

Winters in northern South America and gets back nearly a week later than the oriole

A PERMANENT RESIDENT — THE CHICKADEE

Identified by a band placed on its leg as frequenting the same place throughout the year.

A LONG-DISTANCE MIGRANT — THE YELLOWLEG

The yellowleg sometimes wanders as far as Patagonia but never nests south of Northern Quebec.

The illustrations in this chapter are from photographs by A A Allen

BIRD MIGRATION AND HOME LIFE

The Mystery of Their Travels and the Fascination of Their Home Habits

THE BIRD ON HIS TRAVELS AND AT HOME

FROM the whole field of nature one can select no more engaging study than that of bird migration. The strange calls from the clouds at night, the passage of the well-formed flocks of ducks and geese by day, the flashing of new wings through the garden and the return of familiar voices, inspire us to wonder at the power and precision of the guiding sense that draws birds back each year to their homes of the previous summer. In great waves they come from the South, flood us with beauty and song for a few days, and then pass on. Wave after wave passes over us during April and May until June arrives, when the last immature birds hasten on to their nesting ground and leave us with only our summer birds until the fall migration shall bring them back once more.

A little observation from year to year shows us that the May birds are extremely regular in their appearance and disappearance. One can soon learn just when to expect each species, and if the weather is normal, it will arrive on the day set. The earlier birds such as the robin, bluebird, blackbird, Canada goose, meadowlark and mourning dove, which come during March, are less regular because of the idiosyncrasies of the weather. If there were no such thing as weather and food were always equally abundant, if it were one great level plain from the Amazon to Great Slave Lake, the birds would swing back and forth as regularly as a pendulum and cross a given point at exactly the same time every year. For this migrating instinct is closely associated with the enlargement and reduction of the reproductive organs, a physiological cycle which, under normal conditions, is just as regular as the pulsing of the heart and records time as accurately as a clock. With most species the organs of mature birds begin to enlarge before those of birds hatched the preceding year, and those of the males before those of the females. Because of this, the male birds arrive first and are followed by the females and later by the immature. With some species like the robin, bluebird and phœbe, there is very little difference in the time of arrival, but in the case of the red-winged blackbird, often a period of two weeks or even a month intervenes. This may be a wise provision of nature to insure the selection of a nesting area that will not be overcrowded, for once the male has established himself, and it is often at the same spot year after year, he drives away all other males from the vicinity awaiting the arrival of the females and particularly his mate of the previous year.

But with the later migrants, such as the shore birds, that have a long way to go, the females usually arrive with the males, and with some species courting takes place en route and they arrive at the breeding ground fully mated and ready to nest. The early migrants are those that have spent the winter entirely within the United States. This is true of all the March birds in the Northern States but during the last of the month, the first birds from the West Indies and Mexico begin to arrive in the South. About the middle of April many of the birds that have wintered still further south begin to arrive, including the swallows, the spotted

sandpiper, the black and white warbler and the water-thrush. The last of April and first of May brings even to the Northern States the initial wave of birds from Central America and perhaps even northern South America, and about the middle of this month, when occurs the height of the migration, thousands of tiny warblers, vireos and flycatchers that have been wintering on the slopes of the Andes or the pampas of Brazil are winging their way overhead to Labrador, Hudson Bay and Alaska. The shortest route which one of the very last to arrive, the black-poll warbler, may travel, is 3500 miles, while those which nest in Alaska must fly over 5000. Some of the shore birds which bring up the close of the migration in late May or early June have undoubtedly come from Chile and even Patagonia and still have several thousand miles to go, so that before they reach their nesting grounds again they will have traveled 16,000 miles since leaving in the autumn.

This constrains us to wonder how these tiny wayfarers are able to traverse such tremendous distances and still return so accurately to their homes. That they do so is certain, for many birds have been marked by aluminum bands placed on their legs so that we know that the same bird often comes back to the same place year after year and builds a nest close to the one of the previous year. Not only has this been proved but it has also been shown that many winter in exactly the same place year after year.

At one time it was thought that they followed well-marked highways in the mountains, rivers and coast lines, surveyed, as it were, by their ancestors and unfailingly followed by all descendants. But now it is believed that these highways are followed only so far as they afford abundant food, and when the food supply lies in some other direction they are regardlessly abandoned. What is it, then, that guides them mile after mile in their flights, flights made mostly under cover of darkness and often at altitudes varying from 2000 to 5000 feet above the earth? A "sense of direction" it is now called, an instinct for recording directions as accurately as a compass, which we, having only so crudely developed in ourselves, are at a loss to understand; an instinct which permits birds to travel north, south, east or west and not lose their bearings. For the migration route of most birds is not directly north and south, and many preface their southerly journeys by long flights directly east or west The bobolinks and vireos of the Northwest, for example, leave the country by way of Florida or the Gulf Coast and first fly directly east to the Mississippi Valley to join the others before starting southeasterly on their annual 5000-mile August flight to Brazil, whence they return the following May with even greater punctuality to fly over the same fields and alight on the same fence posts. The white-winged scoters which nest about the lakes of central Canada, upon the completion of their nesting duties, fly directly east and west to the Atlantic and Pacific, where they winter. Some herons preface their migrations by long flights, even to the north, so that occasionally little blue herons and egrets are found in the Northern States during August and September.

With birds that travel such enormous distances, it is interesting to note their rate of advance. While it is possible for birds to travel great distances without rest, as witnessed by the fall flights of the turnstone from Alaska to Hawaii or that of the golden plover from Labrador to northern South America, distances of over 2000 miles across the open sea, they do not ordinarily progress far in single flights. The spring advance of the robin, for example, averages only 13 miles a day from Louisiana to southern Minnesota. The rate increases gradually to 31 miles a day in southern Canada, 52 miles per day by the time it reaches central Canada and a maximum of 70 miles per day by the time it reaches Alaska. It should not be inferred from this that each robin does not ever migrate less than 13 or more than 70 miles in a single day. Probably they often fly more than a hundred or two hundred miles in a single flight, as do, undoubtedly, many of the smaller birds, but after each flight they dally about their resting

place for several days before starting on again, and this brings down the general rate of advance.

The rate of speed at which birds travel is rather difficult to estimate except for the homing pigeons, which can be timed from one place to another, or the ducks and geese, whose conspicuous flocks traveling high over cities and towns can easily be followed. The championship speed for homing pigeons has been recorded as 55 miles per hour for a period of four hours. A great blue heron has been timed by a motorcyclist keeping directly below it and found to be making 35 miles per hour. A flock of migrating geese has been known to be traveling at a speed of 44.3 miles per hour and a flock of ducks at 47.8 miles. The speed of flight of smaller birds is usually less, although when they mount high in the air and start on their migratory flight they doubtless travel faster than the birds one so often passes flying parallel to a passenger train or suburban car.

The vast majority of birds migrate during the night; some migrate both by day and night, and others only by day. The latter are, for the most part, birds that find their food in the open and can feed as they travel. Such are the robin, the kingbird and the swallows. Other birds, like the sparrows, vireos, warblers and marsh birds, that find their food in the seclusion of trees of dense vegetation, migrate entirely by night. The necessity for this is shown when they arrive at the Gulf of Mexico or other large bodies of water where it is impossible to get food of any kind. If they started early in the morning so as to be across by night, they would not be able to secure much food before starting, and by the time they reached the Mexican side, it would be dark and again impossible to feed. Thus an interval of thirty-six hours would elapse without food, a period that might result disastrously for many birds because of their high rate of metabolism. If, however they spend the day feeding and migrate by night, their crops are full and when they arrive at the other side of the Gulf, it is daylight and they can begin again to glean their living.

During these night migrations birds are attracted by any bright steady light, and every year hundreds and thousands dash themselves to death against lighthouses, high monuments and buildings. While the torch in the Bartholdi Statue of Liberty was kept lighted, as many as 700 birds in a month were picked up at its base. On some of the English lighthouses where bird destruction was formerly enormous, "bird ladders" have been con-

WITH A KEEN SENSE OF DIRECTION
Female bobolink perched on a moth mullein.

structed, forming a sort of lattice below the light where the birds can rest instead of fluttering out their lives against the glass. Again in crossing large bodies of water, they are often overtaken by storms and as their plumage becomes water-soaked, they are beaten down to the waves and drowned. Sometimes thousands of birds are killed by a single storm. But of course the vast majority sweep on and arrive at their destinations in safety.

And so if we step out on a cloudy night when the birds are migrating low to escape flying through the mist-laden clouds and hear their strange calls only faintly resembling their familiar daytime notes, we can picture to ourselves the thousands of winged travelers returning from a sojourn in the tropics and pushing on through the black night, guided by an innate sense of direction, pursuing their course straight to their old homes. We can think over the past ages through which this migrating habit has evolved to the days when all North America basked in a tropical sun and birds darted among the palms and tree ferns without ever a thought of leaving the land of their forefathers. Then we can picture to ourselves the coming of the Ice Age and the destruction of all the life that could not adapt itself to the changed conditions or flee before it We see the birds gradually pushed to the southward, encroaching upon those already there. We understand the crowding that ensued and how these birds spread northward again as the glaciers receded, only to be forced back once more with the coming winter Then, with the withdrawal of the ice and the evolution of the seasons, these migrations, by repetition through the ages, became permanent habits or instinct; and with the ensuing modifications in the contour of the continent, and the changes in the location of the food supply, many variations developed in the migration route of each species which seem inexplicable today.

Nest-building and egg laying

In the beginning it might be mentioned that most birds are monogamous, that is, they have the same mates throughout the period of the dependency of the young. With birds the entire cycle from birth to maturity occurs within a comparatively few weeks. The home is built, the eggs are laid, the young are cared for until they become entirely self-supporting, with many birds all within the period of a month or six weeks. With the human species this cycle of events requires anywhere from twenty-one to forty years depending upon the number of children. It is fair, then, to say that birds are monogamous, even though they may change mates from year to year, or even between broods, as is sometimes the case, so long as they do not maintain two mates at the same time. Some birds, particularly those that do not migrate, probably retain the same mates year after year and, even among migratory birds, the same two birds may resort to the same nesting-spot year after year and remate.

We have as yet very little definite information upon this subject, however, and it is one of the problems which "bird-banding" should throw much light upon. In this, as in most aspects of the home life of birds, there is as much individual difference as there is with the human species, which makes it difficult to generalize upon, but most interesting to observe Indeed the similarity of their actions to ours and their responses to ours are so striking that it has led some nature writers to endow them with an intelligence and power of thought that is not justified by the facts Some birds are remarkably faithful to one another while others have much greater attachment for the nesting-site than they have for their mates. If one of a pair of Canada geese is killed or permanently separated, the other remains single for years and perhaps never remates. On the other hand, with the majority of birds, if one is killed, a new mate is secured within a few hours.

A few birds, like the pheasants and, probably, most grouse, are regularly polygamous, and others, like the house wren (and probably other species of wrens), red-winged blackbirds, great-tailed grackles and doubtless other species, frequently so; and individual cases can be expected occasionally with almost any species, should there chance to be a preponderance of females, a condition which rarely happens. Polyandry, the mating of one female with more than one male, may likewise occasionally happen, particularly if a stronger male is able to drive away one that is already mated. It is not regularly the case with any bird unless it be the cowbird, and of its domestic relations we still know too little to say definitely.

A few birds are communistic: they build a common nest in which all the females lay eggs and then share the duties of incubation and rearing the young. This is particularly true of the anis of tropical and subtropical America, though many of the African weaver birds and the palm chats of Santo Domingo are communistic to the extent of building a common roof beneath which each pair builds its nest.

After the birds are mated the first thought, of the female at least, is the building of the nest The male has already selected the general nesting area or territory in which he has been singing and which the female has accepted by accepting him. It is her duty, however, to select the actual site where the nest is to be built and to do most, perhaps all, of the building. With most if not all species of wrens the building of "dummy nests" by the males is a common practice but is apparently rather part of a courtship performance, for they are never used by the female The male house wren, for example, arriving before the female, proceeds to fill every nesting-box and cranny in the vicinity full of sticks and may even build quite well-shaped nests. When the female arrives and accepts him for a mate, however, she does not at the same time accept the home which he has built; for even though she may decide to use one of the boxes where he has already started a nest, she usually proceeds to throw out all of the sticks which he has laboriously brought in before starting a nest of her own making.

The writer has never known any kind of bird in which the males and females worked equally at nest-building, though with many of the common birds the male makes a pretense at helping. It is his duty to see that no other male or even female of the same species intrudes, and this takes so much of his time that, though he may accompany the female back and forth on her trips, he has little left for gathering material. Judging from the way the female usually treats his occasional offerings, it would seem that his lack of experience has so warped his judgment that he does not know the proper material when he sees it.

This brings up the question of what determines the proper nesting material for each species Practically all birds build nests that are characteristic of the species. The materials vary somewhat in different localities depending upon what is most convenient, but, in general, house wrens use twigs, bluebirds use grasses, yellow warblers use cotton, and so on, though often curious substitutes are employed. The writer has, for example, a wren's nest built largely of hair-pins and wire clippings, and a robin's nest in which the customary grasses were replaced by long narrow strips of paper from a near-by paper mill. While the materials with which a bird comes most

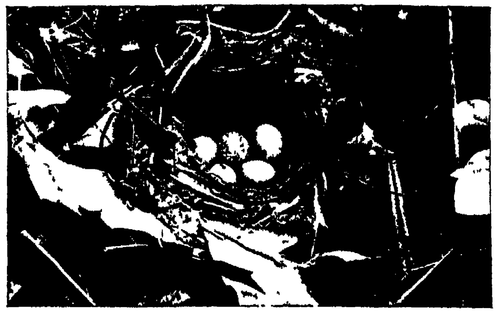
SONG IS INDICATION OF NESTING SEASON
This swamp sparrow is announcing his presence to all females of his species and challenging all other males.

in contact are the ones employed in nest-building, only such materials are used as permit the construction of the type of nest characteristic of the species or family. Baltimore orioles normally weave their nests from vegetable fibers such as the inner bark of milkweed. They will take pieces of yarn or string or horsehair just as readily but never, to my knowledge, will they use sticks, straws or grasses, though grasses are regularly used by the orchard oriole. Marsh birds regularly use dried sedges, rushes or marsh grasses; field birds employ grasses and horsehair; woodland birds use dead leaves, mosses and rootlets, and so on.

THE EVOLUTION OF BIRDS' NESTS

THE SIMPLEST FORM — NO NEST AT ALL!
The whip-poor-will simply lays its eggs on the leaves of the forest floor

THEN, A SLIGHT DEPRESSION IN THE GROUND
The killdeer scoops out a slight depression to hold its eggs



THE DEPRESSION GETS A STRAW LINING AND A PLATFORM OF LEAVES TO RAISE IT FROM THE GROUND

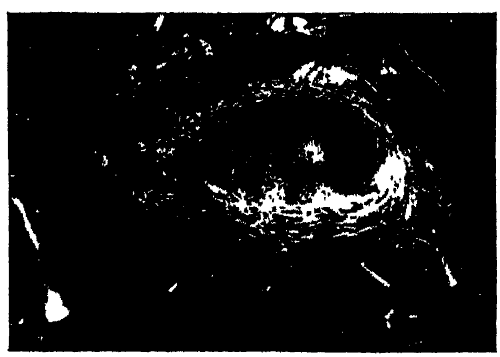
The spotted sandpiper adds a few coarse straws to the depression by way of lining

The speckled egg in this veery's nest is that of the nefarious parasitic cowbird — that knows no home life

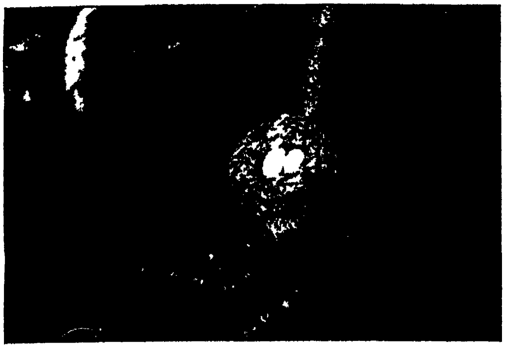
A SIMPLE TREE NEST OF STICKS
The platform of sticks built by the green heron

A MORE COMPLICATED TREE NEST
The catbird hollows the platform and adds a lining of rootlets.

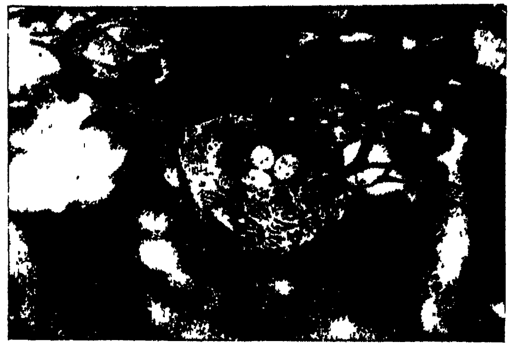
A DISTINCT ADVANCE IN COMFORT
The chipping sparrow uses softer grasses and a lining of horse hair. The large egg is that of a cowbird.



THE VERY HEIGHT OF LUXURY
The yellow warbler employs only the softest materials like cotton and hair.



HIGHLY-EVOLVED NEST OF THE HUMMINGBIRD
Decorated with bits of lichens to make it resemble a knot



ONE OF THE HIGH SPOTS IN BIRD ARCHITECTURE
Pendant nest of the yellow-throated vireo

Birds that spend a great deal of time on the wing and come less into contact with nesting materials and nesting-sites show the greatest diversity both as to site and materials Among our common swallows, for example, the barn and cliff swallows build nests of mud about barns or cliffs; the tree swallows build nests of straws and feathers in holes in trees or bird-houses; the bank swallows build similar nests at the end of holes which they excavate in sandbanks; and the rough-winged swallows utilize old kingfisher burrows or natural crannies about cliffs or bridges or drain-pipes.

The factors that control the selection of the nesting-site are primarily the necessity for concealment, accessibility to the feeding-ground and protection from the elements. If birds were capable of worrying over the possibility of the destruction of their homes, their heads would be white before their nests were started. As it is, they go about the selection of the site instinctively and finally decide upon one which is usually well concealed from their ordinary enemies such as cats, crows, hawks, owls, jays, grackles, wrens, weasels, skunks, raccoons, squirrels, rats and snakes, as well as being fairly well protected from wind and rain, and accessible to their feeding-ground. The large percentage of nests that are broken up, however, attests the many dangers that beset the bird's home and life. It is no exaggeration to state that less than 10 per cent, perhaps not one in twenty, of the nests which are built each year endure until the young leave of their own accord.

Some species of birds are not adaptable and when conditions change they vanish; others are able to change their natural nesting-sites, make the best of things and even increase. Such are the robin, all the birds that nest in nesting-boxes, the phœbe and the barn and cliff swallows which formerly nested only on cliffs but are now common about our dwellings. The chimney swift, which has almost forsaken the hollow trees for the chimneys, is another good example. One often hears of birds nesting in unusual places, like moving street-cars or traveling cranes, under wagons left standing, in clothes-pin bags, in the pockets of scarecrows, etc, but they are always of these adaptable species. It is almost beyond the realm of possibility to have a yellow-breasted chat or a cuckoo or even a catbird behave in such a manner.

Before leaving the subject of nesting we ought to try to answer the question, why birds build nests at all. Some we know still lay their eggs on the ground without any nest whatever, and they manage to persist or else we would not have any nighthawks or whip-poor-wills. The same is true of many of the sea-birds like the auks and murres. At the other extreme are the orioles and the weaver birds, which weave such elaborate nests. Between the two we find all gradations of nest structure from those that merely scoop out a little depression to keep the eggs from rolling, like the killdeer, or those that add a few grasses by way of a lining, like the spotted sandpiper, to those that build rather elaborate domed nests on the ground, like the meadowlark and the ovenbird.

Of the birds that have raised their nests above ground to escape floods or terrestrial enemies, there are some that merely lift them by building a platform of dead leaves, like the veery, or the rails and gallinules in the marsh. Others build crude platforms of sticks in trees or bushes, barely sufficient to keep the eggs from rolling to the ground, such are the nests of the herons, the mourning dove and the cuckoos. Crows and catbirds have advanced a step farther, for while they still use sticks they build deeply hollowed nests and line them with softer materials Nests of the yellow warbler, redstart and goldfinch, made entirely of soft materials, doubtless represent a still higher stage in the evolution of nests that culminates in the beautifully woven structures of the vireos, orioles and weaver birds. Such is the present status of birds' nests, and doubtless it indicates the various steps through which the more complicated nests have passed.

If we would understand the real origin of nest-building, however, we must go back to the earliest birds when their habits of egg-laying were probably about the same as are those of reptiles today. Turtles bury their eggs in the sand; lizards hide them in holes in stumps or decaying logs; snakes bury theirs in decaying vegetation, and alligators build nests of the same material in which they hide their eggs, and are the only reptiles which are said to take an interest in the welfare of the young later on. But, as in all other reptiles, the eggs are hatched by the heat of the sun or from the decaying material.

Now, it must be remembered that reptiles are "cold-blooded" creatures and are not affected by great changes in their bodily temperature, while the warm-blooded birds and mammals, on the other hand, can endure but a very slight change from the normal temperature of their blood without ill effect. What is true of the grown bird is equally true of the embryo developing within the egg. Its temperature must be maintained or it will not develop and will soon die. There are a few birds, such as the megapodes of the Australian region, which still rely upon the method of burying their eggs in the sand or in piles of decaying vegetation, but they lay their eggs at a time when the temperature is remarkably uniform in the places which they select All other birds have to depend upon supplying the heat from their own bodies; that is, they have to incubate their eggs, and it is the need for incubating the eggs that gave rise to the nest-building habit Birds that were in the habit of nesting in holes in banks or in trees, where they could remain with their eggs with no great inconvenience, did not have to learn how to build nests, except in so far as they had to learn to dig their own excavations instead of accepting natural cavities Such is the habit of the woodpeckers and the kingfishers today. They excavate their nesting cavities, but they build no nests within for their eggs. Birds that had been in the habit of burying their eggs, however, and now had to lay them on the surface of the ground where they could be incubated, had other problems to meet. There were the floods, the cold, wet ground, the numerous terrestrial enemies, all threatening to destroy the eggs. It is easy to imagine, therefore, that those individuals that learned to raise their nests away from the ground were the ones that persisted until the habit was formed. The first nests were doubtless very crude and the beautiful structures with which we are familiar are therefore the result of a gradual evolution such as that already indicated.

We have stated that nests are ordinarily built by the female birds though the male often makes a pretense at helping. The time required depends a good deal upon the time at the disposal of the birds, but, with ordinary birds, like robins, or blackbirds, it is about six days. Three days are spent on the outside and a like time on the interior. The same bird, however, if the first nest is destroyed while the eggs are being laid, might build an entirely new nest in a single day. A pair of phœbes, on the other hand, under observation, began repairing an old nest fully a month before any eggs were laid. Usually the nest is completed the day before the first egg is laid.

Incubation does not ordinarily begin until egg-laying is completed, so that all of the eggs will hatch at about the same time Otherwise the first young to hatch would have an unfair advantage over the others in the nest. Occasionally one finds owls or bitterns beginning to incubate before all of the eggs have been laid, but they are, perhaps, less regular about egg-laying than most birds. Most birds lay one egg each day at about the same time, but larger birds, like hawks, owls, and geese, have intervals of two days.

As the time for incubation approaches, the bare area on the middle of the breast becomes suffused with blood and is termed the "blood spot", and the bird becomes "broody". Ducks and geese which have practically no bare area on the breast then proceed to pull out the down from that region so as to bring the eggs in direct contact with the skin. Incidentally, this down forms a blanket with which the eggs are always covered when the duck leaves them to feed.

When both birds are colored alike, they usually share equally the duties of incubation, but when the male is brighter than the female, he is not often seen on the nest, the rose-breasted grosbeak being an exception. Ordinarily, he either stands guard on the edge of the nest until the female returns from her feeding excursions or else brings food to her. Sometimes he feeds her on the nest, but more often he calls, as he approaches, and she flies out to meet him. The easiest way to find a marsh hawk's nest is to listen for the returning male and then note from what spot the female flies up to meet him and takes the food from his claws. The care of the female by the male is carried to the extreme by the African hornbills, in which species the male walls up the opening to the nest in a hollow tree with mud until only the female's bill can be protruded. He then proceeds to bring her all her food and likewise that for the young later on, for she remains imprisoned until the young are nearly full grown. So great is the task of providing food for the whole family, we are told, that he becomes very thin and often succumbs during severe weather.

In a few birds the males do most or all of the incubating and care of the young. This is said to be true of the emus and cassowaries of the East Indies, the rheas and tinamous of South America, of ostriches, at least in captivity, and more particularly of our own phalaropes. In the case of the phalaropes the males not only do all of the domestic chores but they are likewise less brightly marked than the females, apparently a complete reversal of the sexes.

The period of incubation depends largely on the size of the egg and the nature of the young,— larger eggs, those from which precocial young hatch, requiring longer

A DUTIFUL HUSBAND

It is the exception for a brightly colored male bird to assist in incubating, but the rose-breasted grosbeak is here shown relieving his spouse, as he should

periods. The actual time varies from 10 days in the cowbird to from 50 to 60 in the ostrich, or even from 70 to 80 in the case of the emu. Sparrows require from 12 to 13; thrushes, 13 to 14; hens, 21; ducks, from 21 to 30, depending largely on the size; geese, 30 to 35, etc. An apparent exception is the hummingbird, which requires from 14 to 15 days but has the smallest egg of all. This may be due to the fact that she receives no help whatever from the male, and the eggs may become unduly cooled during her feeding excursions, for it is known that unusual cooling of the eggs delays the hatching if it does not entirely prevent it.

The extremely short period of the cowbird is perhaps an adaptation to its parasitic habits, for if the young cowbird hatches ahead of its foster brothers it has a better chance of getting most of the food and either starving them to death or ousting them from the nest.

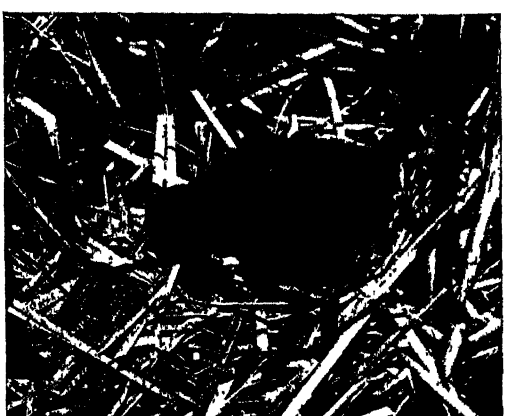
Young birds are assisted in getting out of the shell by what is called the "egg-tooth," a hard calcareous tubercle on the upper mandible which is used as the cutting tool in "pecking" the egg. The bills of all embryo birds are very soft, making such an instrument necessary. This egg-tooth persists for several days after hatching and is quite conspicuous on some birds. Many birds, particularly grouse and quail, cut a neat little cap out of the larger end of the egg with this egg-tooth, but others break the shell irregularly. Most birds are very careful to remove the empty shells from the nests, either swallowing them or carrying them off some distance. Birds that have precocial young, however, that do not stay in the nest for any time after hatching, do not bother with the empty shells.

During the period of incubation the eggs have to be turned once or twice a day so that they will be heated evenly and so that the membranes will not adhere to the shell and prevent the free passage of air to the interior. Some birds turn the eggs with their feet and others with their bills, and usually it is at the time that the female returns from a feeding excursion.

The young birds, their growth and care

Young birds at hatching are of two general types. They are either precocial or altricial. Precocial young resemble chickens in that they are wide awake when hatched, are covered with down, and are able very soon after drying off to follow their parents in search for food, a large part of which they find by themselves. Altricial young, on the other hand, are almost naked when hatched, their eyes are not yet open, and they are cared for in the nest by their parents for periods varying from a week or ten days with terrestrial sparrows, to nearly a year with the condor and the wandering albatross.

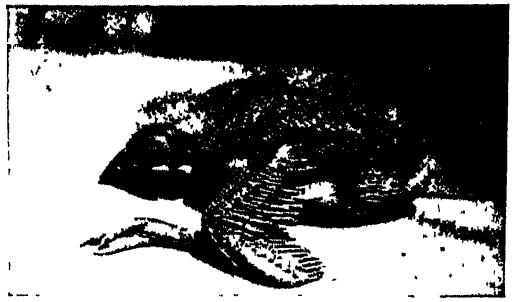
In general, terrestrial, diving and swimming birds have precocial young, while arboreal birds and birds that search their food on the wing have altricial young. Among the former are the loons and grebes, the ducks, geese and swans, the shore birds, the marsh-birds and the fowl-like birds. Some young, such as those of the gulls and terns, remain in the nest or, at least, have food brought to them for weeks, but in other respects are entirely precocial, being wide awake, covered with down, and able to run about shortly after hatching. Other young, such as those of hawks, owls, nighthawks and whip-poor-wills, and even herons, are covered with thick down when hatched but in other respects are altricial, being blind at first and quite unable to help themselves for a long time.



FLORIDA GALLINULE INCUBATING
Incubation is the prime requisite in the care of the eggs.

ONE GOOD TURN DESERVES ANOTHER
The eggs have to be turned occasionally during incubation.

PRECOCIAL YOUNG OF THE RUFFED GROUSE
Covered with down, wideawake, and able to run soon after hatching



ALTRICIAL YOUNG OF THE COMMON CROW
Born blind, naked and helpless A contrast to the day-old youngster on the left.

At the opposite extreme among altricial young are those of the flicker, the kingfisher and the hummingbirds, which are naked. The majority of woodpeckers have a few hair-like feathers when hatched, and cuckoos have them quite thread-like. Young cuckoos and kingfishers are worthy of attention again when they come to attain their first real feathers, for, unlike most birds, they remain in the sheath until nearly full grown. For a time the young birds seem covered with tiny lead pencils and the transformation to the fluffy feathers, by the breaking open of the sheaths, is very rapid, requiring but a few hours. With other young birds, the transformation from almost naked babes into fluffy feathered creatures is gradual. Whatever down there is, is pushed out on the tips of the incoming juvenile feathers, which begin to break their sheaths before they are quarter grown. In the case of a red-winged blackbird, for example, the "pin feathers" have pushed the down entirely out and are well grown by the end of the fifth day, and on the sixth the sheaths of the "pin feathers" have begun to break. Three days later the feathers have unfolded sufficiently to hide most of the bare spots, and by the eleventh day the young bird is apparently fully feathered except around the eye, which area, in blackbirds, is the last to be clothed. Of course, the feathers continue to grow after the eleventh day, but the young bird has left the nest and is already able to fly short distances. The change, however, has been gradual, requiring several days, while in cuckoos and kingfishers it seems to occur within a few hours after the sheaths break open.

When the young hatch they are not fed immediately, the time elapsing before the first feeding varying with different species. The method of feeding likewise varies. Many birds are fed by regurgitation. The parent bird swallows the food and gives it to the young in a partially digested state. Some, like the mourning doves and goldfinches, continue this process as long as they feed the young. Herons and bitterns do also, at least as long as the young are in the nest, and one never sees one of these birds returning to its nest with anything in its bill. Waxwings use their crops as regular market baskets and return to the nest with their necks bulging with a great variety of small fruits and insects mostly in a good state of preservation. With the majority of common birds, however, this method of feeding is continued but a short time, if at all, and it is a familiar sight to see the parent birds returning to their young with insects or fruit in their bills.

The commonest method of feeding is the placing of the old bird's bill containing the food far down into the throat of the young. This prevents any live insect from escaping. In birds that regurgitate food, however, there are several different ways of transferring the food. In birds like the pelicans and cormorants, which bring back fish in their throat pouches, the old bird merely opens its bill and permits the young to rummage around inside. Sometimes they almost disappear down the throat of the old bird. With the herons, as shown in the photograph on the next page, the old bird turns its head on the side and the young grasps it with

a scissor-like action, dilating its lower mandibles so as to catch whatever comes out of the throat of the old bird. To the onlooker, it appears like a very clumsy performance, but little food seems ever to be wasted by spilling. Young mourning doves have swellings at the corner of the mouth which the old birds press when they interlock bills to inspire the proper swallowing action of the young. I once tried to raise a crippled young dove and could not get it to swallow anything, even that which was forcibly put into its throat, until I discovered the nervous adjustment between the swellings and the throat muscles. After that it was easy, for I merely had to touch the swellings and it was like pressing a button. The little bird's mouth opened and the throat muscles commenced to work even before the food entered the bird's mouth.

With all birds there is a nervous adjustment which prevents overfeeding. Birds do not feed their young in rotation, as one might expect, but ordinarily they feed the hungriest one first and continue to feed him until some other one gets hungrier and stretches its neck further and cries louder. This might result in overfeeding the largest young one but, fortunately, when the young bird has had enough, its throat muscles automatically refuse to work further.

So after each feeding the wise old bird looks down into the throat of the young one (the young bird, if well, keeps its mouth open for food as long as the parent is about), and if the last bug is not promptly swallowed, she takes it out again and gives it to one of the other young. It is this habit of feeding the one with the longest neck and widest mouth first that causes the fatalities among the rightful young in a nest where there is a young cowbird, for the cowbird always has the longest neck and the widest mouth, and gets all the food. After the young have left the nest the old birds are not so particular about putting the food far down the throat of the young, for the young bird has soon to catch insects or find food for itself. It is interesting to watch a family of young swallows learning to catch insects on the wing. So long as they are in the nest, they are fed like other young, having the food placed far down their throats, but once they leave the nest, such caution ceases. It is but a short time before the old bird merely sweeps by the young one and drops the food into the open mouth without stopping, and when the youngsters are able to fly, the same operation is employed in full flight It is as though the old birds were teaching the young to catch things out of the air. Young duck hawks learn in much the same way to

NORMAL WAY OF FEEDING

Female redwing feeding its young by placing the food far down the throat of the young bird.

CLEANING HOUSE AFTER IT

After each feeding birds usually clean the nest Here is a redwing attending to his household duties.

FEEDING BY REGURGITATION

Here is a least bittern (a heron) disgorging food for its young in its characteristically ungainly manner

pounce on birds in full flight. When the young are able to fly, the old birds merely swing by the nesting ledge with the food in their talons and the young ones fly out, turn over beneath the old bird and strike at the food as though it were being carried along on its own wings.

The amount of food which birds, especially insectivorous species, require, is always a surprise to one observing it for the first time. The classical experiment of feeding a young robin all the earthworms it can eat at the time it leaves the nest can scarcely be improved upon. The result with the original robin experimented with was fourteen feet of earthworm in one day. Experiments with young crows have shown that they require at least half their own weight of food each day merely to exist and that they can easily consume food equivalent to their full weight each day. Many young crows that are kept in captivity, as well as other young birds, are starved to death because their owners do not realize how much food is required. They do not eat very much at a time but their digestion is so rapid that their parents feed them almost continuously from daylight until dark, and, as Mr. Forbush says, they eat the equivalent of at least eight full meals each day. If one wished to be duly impressed by the amount of food required by a young bird, he should put up an observation blind by a nest of young birds of almost any species. Quite naturally they do not require as much food when newly hatched as when they are ready to leave the nest. Birds that feed by regurgitation and those which bring back large pieces of food naturally do not feed as often as those which make the trips to the nest with only their bills full. Hawks usually feed only about once an hour; hummingbirds, once in twenty minutes, but a pair of chickadees that I watched at their nest last summer made 35 trips to the nest in thirty minutes. A pair of rose-breasted grosbeaks are recorded as feeding their young 426 times in 11 hours, and a house wren, 1217 times in the 15 hours and 45 minutes of daylight.

Young birds, until they have developed a covering of feathers, require frequent brooding by the old bird to keep them from getting cold and likewise to keep them from getting too hot if the nest is exposed to the sun. Altricial young are never brooded after they leave the nest, but precocial young are brooded for five or six weeks (or until they grow their juvenile feathers), wherever it strikes the fancy of the old bird, though seldom in the nest which they have left. A pair of Canada geese, however, that I had in captivity, took their goslings each night back to the old nest to be brooded, though it was not much more than a depression in the ground. Florida gallinules, and doubtless other marsh-birds, as well, often make new nests or rafts of rushes on which to brood their young. Wood ducks, grebes and swans

MALE TOWHEE SCOLDING

often take their young on their backs and brood them beneath their wings. Indeed, the grebes often take this method of conveying their young to safety, closing their wings down tight upon them and diving with them. The European woodcock, on the other hand, is said to convey its young to suitable feeding spots between its thighs, flying with dangling legs, and it is apparently a common practice with rails to seize their young by any convenient appendage and rush them to safety.

The varying degrees of attachment for their young which birds show, and their methods of expressing it, are always interesting to observe. Few birds seem to feel much of a parental instinct when the young are freshly hatched. The instinct increases daily, and reaches a maximum

at the time when the young are ready to leave the nest. The same is true of the bird's instinct to incubate. When the eggs are freshly laid the bird will desert them readily, but at the time when they are hatching, even the most timid birds will cling to the nest in the presence of danger. Bird photographers should always bear this in mind and never try to photograph birds at their nests when they are just beginning to incubate or just beginning to brood. Most hawks, herons, cormorants, pelicans, yellow-breasted chats and

CANADA GEESE DEFENDING THEIR NEST
The goose covers the eggs while the gander engages in active combat with the intruder (birds nesting in captivity).

mourning doves have their parental instincts very poorly developed, and readily desert their eggs or young in the presence of danger. Most chickadees, and a great many warblers and vireos, on the other hand, have their parental instincts so highly developed that they pay no attention to dangers while they are incubating or brooding. At least they will permit a very close approach, and even let one stroke them while they cling to the nest. Between the two extremes there are all gradations, no two birds behaving exactly alike in the defense of their nests or young.

Many birds feign being wounded in an attempt to lure one away from the nest, and drag themselves pitifully over the ground in the hope that the enemy will follow them and lose track of the nest or young. Other birds dart at one's head and attempt to inflict blows with their bills, their wings or their talons, while the majority merely express their distress by loud calls which attract all the other birds to the vicinity.

It is interesting to observe the varying times at which fear first develops in the young birds. It is apparently instilled into them by their parents, because when eggs from wild birds are hatched under domestic birds the young seem never to develop the sense of fear for human beings. There are some exceptions to this statement, however, especially among precocial birds, many of which are extremely timid even when hatched under most quiet hens and lose their fear very gradually. In the wild state, precocial young seem to respond to this fear instinct as soon as they have dried off and are able to run. With altricial young, on the other hand, it is not until they are developing their feathers, a few days prior to leaving the nest, that they crouch and try to hide at one's approach. Before that time, they stretch up their necks and open their mouths for food just as freely for a human being as for their parents.

It is about the same time that the young birds apparently come for the first time to the realization of the meaning of the different calls of their parents and crouch for one note, stretch up their necks at another, or remain passive for a third. Anyone familiar with poultry knows of the various calls of the old hen to her chicks. Her vocabulary is not extensive, but no one would deny the fact that she has a method of conveying many different instructions to her chicks. They all crouch when she cries hawk, they scatter when she cries cat, and they rush to her when she cries food, etc. Other birds are just the same, but it takes a discerning ear to catch the differences in notes, and it is impossible to put them in print. Distress calls are usually recognized by all species of birds, and they fly to the scene of trouble.

Whether the other notes are understood by all species or whether each species has its private language, we have no very good way of knowing. It is a study that will take a refinement of observation that we have not yet attained.

It is said that the call notes of a bird are instinctive and that its song is learned by imitation, but the latter statement has not been entirely proved. Certainly a crow will caw and a duck will quack whether or not it ever hears any others of its kind, and I am inclined to believe a robin would sing like a robin if it never heard another bird sing. But when young birds are raised by other species, never hear their own kind and continually hear the songs of their foster parents, they do seem to acquire songs resembling more those of their foster parents than their own. We should remember, however, that the power of imitation is quite general among birds and not confined to the mockingbirds alone, though with them it reached its greatest perfection. The only fair test would be to raise a young bird to the singing age without its hearing any other song. So far as I know, this has never been done.

All young birds by the time they leave the nest have well-developed distress calls and food calls. Some young like the Baltimore orioles and the Florida gallinules never stop calling except when notified by their parents that danger is near. Other young call when they are hungry or think they are lost, and thus, though the brood may be quite scattered, the parents are able to keep track of them. Many persons, finding a young bird without its parents, think it has been deserted and feel that they must take it home and feed it. This is a mistaken kindness for, usually, it merely signifies that the brood is somewhat scattered, and that the parents are busy feeding the other young; particularly is this so if the young bird is quiet, for that indicates that he has just been fed and that the old birds may not be back for some time. If the young bird is put up out of reach of cats, the parents will sooner or later find it and care for its for its food call will carry as far as it could possibly fly since its previous feeding.

The syrinx of a young bird, and therefore its song, does not fully develop ordinarily until the winter or following spring, though I believe there are instances of domesticated song birds singing the same year they are hatched. It is not the case with wild birds, however, though some of the shaky voices that we hear in the fall may possibly be from early hatched birds.

The time required for the young bird to acquire its full plumage varies with different species. Ordinarily, by the time the wing feathers are full grown the body feathers of the juvenile plumage begin to drop out and the first feathers come in. If the male and female are alike, this plumage, which is usually fully acquired by September, will be almost indistinguishable from that of the adults, but,

LEAVE IT ALONE

It is a mistaken kindness to carry a young bird home and try to feed it under the impression that it is lost Its calls for food will ordinarily bring its parents This is a young yellow-breasted chat, not calling because it has just been fed

in brightly colored birds of species in which the male and female are different, it will resemble the female or the male in winter plumage. The next spring it will have a complete or a partial molt of its body feathers to bring it into its breeding dress just as in the adult. Immature scarlet tanagers and goldfinches and indigo birds then closely resemble the adults, being only slightly less brilliant. With some of the warblers, however, like the redstart and myrtle warbler, there is but a slight molt and the immature male still resembles the female with a few of the male feathers. This often results in the recording of female birds singing. Some birds seem to require even more than the two years to acquire the full brilliancy of plumage, but ordinarily after the second year the health of the bird more than its age will affect its plumage.

THE FIGHT FOR THE LIFE OF THE CHILD—FROM THE PAINTING BY JOHN BURR

THE ELEMENTS OF EMOTION

An Analysis of Man's Principal Primary Instincts, and Their Expression as Emotions

THE COMING OF FEAR, WONDER AND LOVE

THANKS to the labors of those who have devoted themselves to the great borderland between biology and psychology, we have been able to define the instincts in man, to see them in their due importance, and to realize that every instinctive act is the outward and visible sign of an inward and psychical state called an emotion. When we realize, further, that these pairs of instincts and emotions are what move us — that they are the veritable motors of man, the springs of our being, the pulse of the machine, and that the balance between them, in any personality, makes the essential difference between a Napoleon or a Washington, a Nero or a Marcus Aurelius — we shall agree that no study of these fundamental architects of human history and destiny can be too sincere and detailed.

In this place, of course, our account must be summary, but, at any rate, the dominant emotions and instincts can be dealt with; and the reader who wishes to go further will consult Dr. McDougall's "Social Psychology", in which, for the first time, this question is seen and stated in its proper proportions. Here we can at least observe the main features of such emotions as wonder, anger, pity, fear, tenderness, which we consider ourselves entitled to call primary. Let that last word be noted. In chemistry we are all agreed that things must be analyzed before we can understand them. We must get down to primary things. In chemistry we must resolve the molecule of water into its two constituent elements of oxygen and hydrogen. So with the mind.

For ordinary purposes, just as water is water and that is good enough, we may talk of love, of conscientiousness, of patriotism, or other states of mind, as if they were primary, elementary states of mind But directly we want real knowledge, to distinguish the kinds of love and conscientiousness and patriotism, the real and the false, the selfish and the unselfish, and so on, it is necessary to effect a sort of chemical analysis of the mind, so as to get at its real, primary elements This is one of the great tasks of psychology at the present day, not least because it is directly complementary to the work of the science of genetics, which also studies the elements of the human constitution and the manner of their hereditary transmission. Both the genetic student and the psychologist fail and find chaos when they take complex things for simple, and both find order and reason when they succeed in this fundamental task of analysis.

We duly note and accept, therefore, the term "primary emotions", and sharply distinguish them from such things as sentiments, dispositions, creeds, and what not, which are complex products of simpler things — always, no doubt, with primary emotions as their root. And if we can credit invisible things with reality, as many persons cannot, we shall try to realize that these primary emotions, and the instincts which are their outward and effective aspects, are as definitely the fundamentals of the mind as, say, the skeleton, the nervous system, the lungs, the circulation, are the fundamentals of our bodily organization.

It was observed that the true emotions and their instincts are common, in large degree, to all individuals of any given species, and that they make for life. They have what Professor Lloyd Morgan has happily called "survival-value" That is why they are there, why evolution has framed them, and why they are and must ever be important, even in so sophisticated and almost more-than-natural a species as man Nowhere is this characteristic better illustrated than in the *instinct of flight and the emotion of fear*. Low down in the animal scale, this instinct may not be necessary, but, anywhere in the neighborhood of our own species higher up, we find it very marked and very important. We may suppose that, say, the tiger or the lion knows no fear, but that is untrue even of the adult. The young of lion or man that knew no fear would never reach adult life; such a species would have no history and would leave no trace.

The association of instinct and emotion as seen in flight and fear

The association of instinct and emotion is here unmistakable. One does not need to be a psychologist to know that flight and fear have something to do with each other. Their strength varies in different species, though any individual of almost any species will run for its life when it must. As a general rule the manifestations are much stronger when they are most necessary, as in children and in women, in our own species. The various physiological facts of fear and of its extreme and dangerous form, which we call terror, are familiar enough. What we know less well, perhaps, is the purpose of them in their normal form.

In instantly paralyzing terror there is only frustration of the natural purpose, but we may probably be convinced that the tense limbs, the deep respirations, the strongly and quickly beating heart of fear, are for the vital purpose of effective flight. And we shall be wise, henceforward, in noting the physiological and instinctive phenomena associated with any emotion, to search for an effective use and purpose in them, as in this case.

Instinctive cries and alarms and their surviving effects on men

The human being, in the young state, is frightened very often by animals. Even the grown man may have a little thrill of fear and a tendency to run when a dog barks at his heels. He is frightened, too, by noises, especially of low pitch, suggesting a hereditary alarm at the voice of the large carnivores, and often by high winds The reactions are very decided. The frightened child is apt to produce an instinctive cry. The "survival-value" of such a cry is evident, for it brings the mother to the rescue. As for the tendency to paralysis which extreme fear may induce — a tendency which may be disastrous if it supervene too soon, for then we do not escape, but are "rooted to the spot" — it is not quite morbid, after all, for it may be a natural aid to the motionless concealment which is the primitive object of flight. Even the adult may hide his or her head under the bedclothes when alarmed at night. But, whether in the child or the adult, the unknown, as such, is a great agent of fear. Hence our fear of the "supernatural", the mysterious, the inexplicable, especially if it be on a large scale.

Thus fear is a primary constituent of those highly complex emotions which we call awe and reverence, and plays a conspicuous part in all religions. As Dr. McDougall says: "It is thus the great inhibitor of action, both present action and future action, and becomes in primitive human societies the great agent of social discipline through which men are led to control of the egoistic impulses."

Is society held together by fear of the policeman and the hereafter?

Probably the word "primitive" is superfluous. If there were no fear of the policeman or of the hereafter, it is doubtful whether civilized society would last for one day. Alike for societies as for individuals, it is probably true that, as Burke said — thereby crystallizing the biology of the subject — "Fear is the mother of safety."

In some ways the instinct and emotion we have discussed are supremely important. So much cannot be said, perhaps, for *the instinct of repulsion and the emotion of disgust*, though our modern knowledge of the nature of disease, and its origin largely in putrefying and disgusting material, may suggest that repulsion and disgust are as necessary to our lives as anything else. Disgust is clearly allied to fear, because they both issue in aversion, and often go hand in hand The notable difference is that, while fear induces flight, disgust induces us to deal with the offensive thing, as when, with a face expressing the emotion of disgust, we spit out a mouthful from a "bad" egg.

Why do we shrink from snakes with an instinctive disgust?

Some historical interest attaches to the repulsion and disgust, accompanied by a "creepy" shudder, that are excited by slimy, cold things, such as snakes. There can be little doubt that snakes were the chief enemies of our remote ancestors, and that it was snakes that they and their young had, above all, to fear. It is notable that we apply this instinct and emotion in the moral sphere. Thus, we say of a man that his character has an evil odor, that it makes us sick to think of him, that he is rotten to the core, and we experience and display the phenomena of disgust at the thought of him, though he may be the best-groomed and physically most pleasing person in the world.

The instinct of curiosity and the emotion of wonder are not nearly so powerful in the lower animals as in ourselves, whom the apes approach most nearly in this respect.

From the point of view of "survival-value", curiosity may seem relatively unimportant, or even inexplicable, for curiosity may lead into danger. But if we consider the conditions of the survival of our own species in the world in terms of knowledge, and if we ask what induces to the gaining of the knowledge whereby man survives and masters the world, we must reply that it has its root in the instinct of curiosity and its correlative emotion of wonder.

How knowledge is rooted in curiosity and wonder

Those men in whom this instinct is strong, and in whom, by practice, it becomes stronger, are the men of science and the thinkers. In them it becomes the great motor of intellectual effort; and most of the greatest and most disinterested achievements of the human mind have this as an essential part, at least, of their source. It is thus one of the principal roots both of science and religion; and we must reasonably connect the infant which puts any strange object to its sensitive lips, so as to learn about it, and which reaches out its hand to anything bright and unknown, with the astronomer who reaches out, with the same motor behind him, for an unknown star or planet. It is a fact of this instinct that, if neglected or overwhelmed by others, it tends to atrophy. Many a bright and intelligent child, eager to learn, full of wonder and interest, turns into a mature person who cares for none of these things.

How the instinct of pugnacity and emotion of anger come into play

The mixture and alternation of fear and curiosity, the impulse to run and the impulse to advance and inspect, are often illustrated in ourselves, and in children and in animals, as any observer of a puppy in presence of some small object that emits noises, for instance, may testify. And, at last, a third instinct may be excited with disastrous results to the object in question — namely, *the instinct of pugnacity and the emotion of anger*. Here is an intense and potent instinct, which ranks in those respects with fear. In the female sex generally this instinct is much weaker than in the male; and some people there are in whom, we might suppose, it does not exist. Even in the gentlest and best-tempered, however, we may at any moment be surprised to find pugnacity and anger aroused in connection with the ill-treatment of the young or helpless. In the case of many animals, the female exhibits pugnacity or anger only when she and her young are molested.

Apart from this special relation to an instinct which we shall later describe, pugnacity and anger specially show themselves, for most people, in relation to food. As Dr McDougall says — "The most mean-spirited cur will angrily resent any attempt to take away its bone if it is hungry; a healthy infant very early displays anger if its meal is interrupted; and all through life most men find it difficult to suppress irritation on similar occasions"

The new forms taken by pugnacity and anger in civilized man

The "cur" tends to bite; and in Darwin's book on "The Expression of the Emotions" we learned how the raised upper lip of anger is none other than a preliminary to biting, while the loud voice of anger is shared by many of the lower animals when they are angry, and try to cow their enemy by roaring or bellowing at him But in the higher types of mankind pugnacity and anger cease to express themselves in this crude fashion They are decadent and disappearing, we should once have supposed, but this is far from the case. They are there all the time, if we will look for them properly They are there in the persistent energy, essentially pugnacious, with which a man or woman of this type works towards some end, obstacles notwithstanding; and when this pugnacity and transmuted anger are combined with the parental instinct and its "tender emotion", we find the great reformers of injustice, the great champions of the liberty of the oppressed, such as Abraham Lincoln, who honor and exalt mankind.

A French student, Théodule Armand Ribot, was the first to appreciate the importance, as primary emotions, of what he called "negative and positive self-feeling", and what we may here call the *instincts of subjection and self-assertion, and the corresponding emotions of subjection and elation.*

The names are clumsy, but the facts are very real, and play an immense part in our lives. If we are ever to understand the psychology of character and of will, we must do justice to those instincts and to the emotions which accompany them.

The part of self-assertion and display in the drama of the mind

There is no doubt about the existence of the instinct of self-display in the lower animals, in children, or in ourselves. The tail of the peacock is an instance of a structure which seems to exist for this display. The horse knows how to display himself, or "show off", with his tail raised, his movements a little exaggerated and "affected", like those of an adolescent boy or girl, when he or she is also showing off. This instinct and its emotion are necessary constituents of the sentiment which we call pride.

The instinct of self-display and its accompanying elation can be seen very conspicuously in children, most of whom love showing off, and are only too freely encouraged to do so by admiring parents As for their fine clothes, or riding a bicycle or even playing games, they usually find them rather dull if there is no one to look on What in baseball is called "*playing to the grandstand*", however it expresses itself, arises from this instinct. The mature man or woman has practised little introspection who supposes that this instinct does not manifest itself, in rather subtler ways, throughout the lives of most of us.

An analysis of feminine motives in wearing fine clothes

The case of clothes is specially interesting to the psychologist, because common, thoughtless judgment makes so little discrimination. Two women may both love and wear beautiful clothes, and may both be put down as vain. Yet, in the one case, the motive impulse *is* vanity, the desire to show off, the instinct of self-display, with its emotional accompaniment of elation.

This woman wears her fine clothes in order to be looked at. In the second woman, superficially of the same psychical type in this particular, the instinct of self-display may be so weak as to be practically absent. She wears her fine clothes for æsthetic reasons, from a love of beautiful things, and from a liking for what is ele-

gant and clean and delicate. She may intensely dislike being stared at. She wears her beautiful clothes for their beauty, and may not have any vanity of the ordinary kind in her. The first woman may be readily distinguished from the second by the fact that she is careless and negligent of her dress when no one is there, and that the unseen part of her attire is of an entirely different order from the external covering which is flaunted before the eyes of men. The second woman becomes more particular about her clothing the more intimate its relation to her person

The opposite instinct and emotion to the self-display and elation which we have defined are no less real. The emotion of subjection, both in the case of a small dog, very often, in the presence of a big one, or in that of a child, safe on its mother's knee, not afraid, but *bashful* in the presence of a stranger, is definitely and specifically accompanied by a certain course of instinctive behavior which we can observe from without in such instances. They furnish us with the true instinctive-emotional root of what we call bashfulness or shame, no less than the opposite states furnish us with the root of vanity and "side", what the English call "swank".

Students of the mind diseased are only too familiar with combinations of symptoms, described in all the textbooks, which receive a deeper interpretation from the foregoing analysis.

Depression and exaltation as phases of the decay of the mind

There is a malady known as "general paralysis of the insane", a form of poisoning of the brain, presumably with a special action upon the basal ganglia, though this point has scarcely been investigated. Its victim, practically from first to last, is in a state of exaltation. He dies in a state of appalling degradation, mental and bodily, but of entire happiness. In the earlier stages especially he boasts of his means, his connections, his accomplishments, his charms, fancies himself a monarch of all he surveys, exhibits every sign of elation.

The psychological interpretation of all these symptoms would now be that the instinct of self-display is morbidly exaggerated and that the rest follows. The "megalomania" (Greek great + madness), the delusions of grandeur, the lavish expenditure of imaginary millions upon trifles, — all these denote the attempt of the patient's intellect to account for and justify the extraordinary state of elation of which he is the subject.

The opposite picture is no less familiar in asylums for the insane. The victim of melancholia, in contrast with the "exalted" patient, "shrinks from the observation of his fellows, thinks himself a most wretched, useless, sinful creature, and, in many cases develops delusions of having performed unworthy or even criminal actions."

Morbid exaggeration of the instinct of self-abasement in the insane

"Many such patients declare they are guilty of the unpardonable sin, although they attach no definite meaning to the phrase — that is to say, the patient's intellect endeavors to justify the persistent emotional state, which has no adequate cause in his relations to his fellow-men" No doubt the true psychological basis of all these symptoms is a morbid exaggeration of the instinct of self-abasement and the emotion of subjection — and the rest follows.

What may be the explanation of this morbid change is a deeper question still, as yet unanswered. But it is an interesting fact that the kind of theory expressed in the ancient name of "melancholia" is beginning to return. That name means "black bile", the theory being that the victim of depression simply suffers from poisoning by means of black bile. The modern view of such melancholia, as, for instance, often follows influenza, is that it is also toxic.

At present, however, students of insanity have not followed up the psychological clue which seems to be offered here. The cerebral cortex of man is so wonderful, so distinctive of him, that the study of the brain in relation to insanity has almost exclusively concerned itself with

the cortex alone The long-standing error as to the essential nature of insanity has contributed to this mistake We say a man has "lost his reason", and popular opinion, the law, and, until lately, medical opinion, thought of insanity as a disease of the "mind", meaning thereby the reason or intellect The patient's belief that he has committed some impossible crime, or that he is a king, is looked upon as the essential fact of his malady; and if we are to seek for a physical cause we suppose that it must be in the *cortex cerebri*, the undoubted seat of the intellect.

The probable seat of the instincts and emotions the basal ganglia of the brain

But all this may be wrong The patient's delusions, his intellectual symptoms, are entirely secondary, as the account we have given shows The malady is not disordered reason, but disordered emotion and instinct, with secondary intellectual symptoms, which catch our attention, to the exclusion of essentials. Our search, therefore, in the sphere of morbid anatomy should be directed towards the probable seat of the instincts and emotions — namely, the ancient collections of nerve cells at the base of the brain. In fact, the morbid changes in this part of the brain, except such as are due to accidents like the bursting of a blood-vessel, of no importance in this connection, have never yet been studied. It is not improbable that such study of the basal ganglia, together with the use of chemical tests, would substantially advance our knowledge of certain insane states.

The parental instinct and emotion of tenderness in the mother

We now come to the seventh and last of the dominant, definite, primary instincts and emotions of man — namely, *the parental instinct and the tender emotion.* Needless to say, a language so rich as English should provide us with suitable words for the emotion here indicated. Probably "tenderness" is the best, but "love" would be far better, if it were not that the whole vocabulary of psychology is so constantly mishandled and so frequently soiled in ordinary speech that it is almost worse than useless for exact purposes. At any rate, tenderness or tender emotion is what we mean; and it is the affective, psychical aspect of those instinctive actions which we recognize as parental, and which, among ourselves as in the case of most species — there are singular exceptions among the insects — are best displayed in the female sex. Of all aspects of mankind, none has been so extensively worshiped, none so frequently depicted upon canvas, as the activity of this instinct and the expression, in face and hands, of this emotion Tender emotion is, above all, aroused in the normal human mother by the spectacle of her helpless offspring. Its impulse is to afford physical protection to the child. especially by throwing the arms about it; and this gives the mother delight and satisfaction, even though the child is in no need of protection, and was, in fact, safely snuggled in its cot a moment before. She is also strongly inclined to kiss the child, an act which, to some, seems to be closely allied to the impulse to lick the young, which is a marked feature of the parental instinct in many animal mothers.

Tenderness neglected as a study by unemotional philosophers

This definite parental emotion of what we here call "tenderness" is not to be confounded with sympathy. They are closely allied but they are not the same, as Ribot clearly saw. This primary emotion, which is of quite incalculable importance for mankind, has been ignored or misunderstood by psychologists in the past to an extraordinary degree, largely, no doubt, because this emotion, on the whole, is much weaker in men than in women, and may, perhaps, be notably so in the type of men who become professional thinkers. Alexander Sutherland, in his book on the "Origin and Growth of the Moral Instinct", takes rank as the first effective student of this subject. No recognized thinker before him saw its full importance, and no one since has had any excuse for underrating it.

Sutherland showed that the parental instinct, as exhibited by the mother, is common to almost all the higher species of animals. As the forms of animal life ascended from the fish, which may produce a million eggs or more, the number of eggs or young is persistently reduced, while their lowered numbers are compensated for by parental protection. This process culminates in the paradoxical case of man, who has the lowest birth-rate, but alone of all species persistently increases in numbers

Parental care may begin by being purely mechanical, and always retains a mechanical element, but we soon see modifications of behavior in its interest and accompanying exhibitions of feeling. Herein we "instinctively" recognize something high, beautiful, almost divine and creative, in the manifestations of life; and thus mother- and child-worship has been a conspicuous or central element in many of the great religions of mankind.

A mother's love the most selfless and exalted of emotions

We cannot but regard this instinctive act and its emotional correlate as the highest, most selfless thing we know. It so directly makes for life, and it is so conspicuously opposed in outcome to the natural action of the other instincts. Primarily, at least, they are for self, this is for another.

In its highest form the parental instinct becomes the chief agent in the maintenance of the species. The mother produces only a few young, but she devotes herself to them so well, and so long, that most of them reach maturity. As has been well said, "In such species the protection and cherishing of the young is the constant and all-absorbing occupation of the mother, to which she devotes all her energies, and in the course of which she will at any time undergo privation, pain, and death. The instinct becomes more powerful than any other, and can override any other, even fear itself; for it works directly in the service of the species, while the other instincts work primarily in the service of the individual life, for which nature cares little."

The shallow reasoning that has pretended to explain a father's love

The parental instinct was no doubt maternal in origin. Among most fathers far back in the line whence we are descended there is little or nothing of it to be seen. How, then, are we to account for the fact that it occurs also in many men? One explanation is the transference by heredity of a character originally evolved in one sex to the other. Support would be furnished for such transference by its "survival-value", for the offspring that has two devoted and loving parents is better off than if it had only one. The truly astonishing fact is not that the parental instinct and its tender emotion exist, but that past psychologists have taken such wrong views of them. Yet, if we do not recognize this primary emotion as "deeply rooted in an ancient instinct of vital importance to the race", we shall have to invent strange explanations for it.

Professor Alexander Bain thought that parental love was generated in the individual by frequent repetition of the intense pleasure of contact with the young; but whence and why this pleasure? Others have suggested that parental love is due to the parent's expectation of being well cared for by his child when he is old! Bain deliberately said that parental emotion is selfish, and that we are "looking all the while at our own pleasure and to nothing beyond". Teaching of this kind was inevitable when philosophers started out with the fixed belief that all our actions are essentially egoistic, and that all morality has its root in social convenience or custom or imitation.

How the "common" and the "uncultured" daily give their lives for others

No modern student can have anything to say to such a doctrine, of which Dr. McDougall thus disposes: "This doctrine is a gross libel on human nature, which is not so far inferior to animal nature in this respect as Bain's words imply. If Bain, and those who agree with his doctrine, were in the right, everything the cynics

have said of human nature would be justified; for from this emotion and its impulse to cherish and protect spring generosity, gratitude, love, pity, true benevolence and altruistic conduct of every kind; in it they have their main and absolutely essential root, without which they would not be Any seemingly altruistic action in which it plays no part is but a sham, the issue of cold calculation or of habits formed under the influence of rewards and punishments."

Germ of all that moral indignation upon which the idea of justice is founded

We have already referred to the close organic relation between the tender emotion and the emotion of anger, as in the case of the tigress robbed of her whelps. Here we have the true genesis of one of the great factors of human society The anger evoked when the parental instinct is outraged is the germ of all that moral indignation upon which the idea of justice is founded. For the survival of mankind it has been necessary that, at any rate in a sufficient number of people, tender emotion and the act of protection shall be evoked not merely by the cry of one's own child, but by the cry of any child — and hence of any one in the position of a child, any one who is ill, unhappy, oppressed, weak, in danger. Every day in the year we hear cases where "common", "coarse", "vulgar", "uncultured" men, perhaps hard-drinking and hard-swearing, have given their lives for a child or a friend, in a coal-mine, on the high seas, in the surf, under the influence of this emotion, which is so markedly superior to all our other attributes that high and low, civilized and savage, alike worship it.

Sympathy an infection; and tenderness an elementary instinct

The psychologists of the nineteenth century, denying the existence of parental tenderness as a primary emotion, had to explain it somehow, and sometimes did so, in a not unplausible fashion, by confounding it with sympathy. Sympathy is literally "feeling-with", and it means neither more nor less than that the sympathetic person feels in him or herself the feelings whose exhibition is witnessed in another The world is full of sensitive, sympathetic people, who dare not even witness the spectacle of pain, are easily disgusted, and must shelter themselves Their method is to avert the gaze from the painful spectacle and look resolutely elsewhere, like the scribe and the Pharisee who passed by the stricken wayfarer, and who, as Dr. McDougall says, "may well have been exquisitely sensitive souls, who would have fainted away if they had been compelled to gaze upon his wounds". But in the good Samaritan, tender emotion was so powerfully evoked that, however painful or even disgusting the situation, he had to stay there and do something.

Primary instincts that exist independent of their racial purpose

No one will question the real distinction between these two things who has any experience of, for instance, amateur nursing of the sick, and the hosts of persons who are so sympathetic and thereby so untender as to be worse than useless The practical surgeon is like the practical mother, who, when her child cuts its finger, does not faint away to show how sympathetic she is, but does something on the spot, and faints afterwards, if she has nothing better to do.

There are other primary instincts, notably *the instinct of reproduction and the emotion of sex-feeling*. We do not experience this as an instinct of reproduction, for it has already been shown that, as William James insisted, an instinct exists independently of any recognition of its purpose We have carefully avoided calling the emotion which accompanies this instinct by the name of "love", which should be reserved for a more complex sentiment. But in our attempt to analyze that sentiment to which the name of "love" — as between the sexes — may rightly be applied, we must note that the reproductive or racial instinct tends to be coupled with and blended in the parental instinct, so that he or she who is the object of our sex-feeling tends also

to be an object towards whom we feel tender emotion and the protective, primarily parental instinct When these are blended, we are much nearer "love"; when there is no addition of the tender emotion to the sex-emotion, then its name, of course, is not love, but lust.

The curious case of creatures that are gregarious but unsociable

We must also recognize the *gregarious instinct*, with the unnamed state of emotion which is associated with it, and of which Defoe gives some hint when Robinson Crusoe discovers a footprint which is not his own. In his "Inquiries into Human Faculty", Sir Francis Galton described this instinct in the South African ox, which is miserable unless it is amid its fellows, but then takes no notice of them. Like many men, who hate to be alone, but yet want no companion, they are gregarious, but unsociable. The survival-value of the instinct which prevents an ox from straying away, towards the claws and jaws of a carnivore, is obvious; and a similar argument must once have applied to man in the early days of his history when in their contests with the mammoth and the larger carnivores the primitive peoples proved the strength of combined effort. The necessity for organization into tribe and clan for purposes of war and associated labor also did much to foster this instinct. The almost universal demand for a crowd, when one wants enjoyment, is based on this instinct.

There is also to be recognized apparently an *instinct of acquisition*, which early leads us to collect things — stamps, coins, etc — and which either yields to subtler variations of itself in later years, or becomes excessive and mad, as in the miser or the kleptomaniac. No name exists for the state of emotional satisfaction which accompanies the exercise of this instinct, but that there is such a genuine and primitive satisfaction can be seen in the disconsolate child that dries its tears and beams with pleasure when some passenger in the street car hands over to it a fistful of obsolete transfers.

The fine instinct that has made man a builder not to be baffled

And, lastly, there is an *instinct of construction*, which gives us a delight in making things The thing made may be a child's sand-castle or a "Synthetic Philosophy", to which thirty-six years are devoted; or a vast epic poem, comprising the history of the world, which no one will ever read; or a Brooklyn Bridge, or something cut with a bracket-saw; but underlying all such activities we see the working of this constructive instinct, which has, beyond a doubt, played a great part in the development of civilization, and which probably ought to hold a special place in our esteem, as being distinctively human, a characteristic and invaluable attribute of the "tool-using animal". It is this "architectonic faculty", as some have called it, that impels a man to complete some task he has undertaken, long after the first glow of interest and excitement has cooled. Those who have it not may often start out on enterprises, but they do not "finish what they start".

The place of sympathy as a bond between the emotions

Finally, let us appreciate the place of sympathy in relation to the emotions. It is not itself an emotion, but it is the process by which one man's emotion infects, or is induced in, another, like the induction of an electric current in the secondary coil of a battery. Fear, curiosity, anger, laughter, melancholy, terror — all of these are capable of being communicated from one person to another by this process we call sympathy. Especially in children do we see this, from the baby which cries when another cries, to the older child which is sad when we are sad and merry when we are merry, and which we love accordingly We all value this quality in our companions, who "rejoice with them that do rejoice, and weep with them that weep" Thus we can clearly understand that sympathy is not an emotion, and what its simple relation to the emotions really is.

THE NORTH POLE AFTER COMMANDER ROBERT PEARY'S VISIT TO IT

PEARY SCANNING THE HORIZON FOR SIGNS OF LAND NEAR THE ICE-COVERED OCEANIC POLE

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EXPLORERS VI

ROBERT EDWIN PEARY—THE DISCOVERER OF THE NORTH POLE

MARCO POLO—THE GREATEST OF ALL LAND EXPLORERS

ROBERT EDWIN PEARY
The American Who Found the North Pole

REAR-ADMIRAL ROBERT EDWIN PEARY was born at Cresson, Pennsylvania, on May 6, 1856. After studying at Bowdoin College, in Maine, he became a civil engineer in the United States Navy in 1881. Three years afterwards he assisted in surveying the course of the inter-oceanic canal which at that time we thought of constructing through Nicaragua, and in 1887 he was made engineer-in-chief of the Nicaragua canal survey. But he had already begun his attack upon the North Pole by a reconnaissance, in 1886, of the inland ice-cap of Greenland.

All his leisure time for the next five years was devoted to studying the conditions of arctic exploration, and preparing his plans for his expedition of 1891. He rounded Greenland, breaking one of his legs on the voyage, marched across the northern end of the vast, glacier-covered island, and discovered Independence Bay. In 1893 he spent two more years in the Arctic, working among the Eskimos of Smith's Sound, and, in the course of his wanderings, found huge meteorites near Melville Bay.

In July, 1898, he again set out north for the purpose of exploring the lands above Greenland, and attempting the North Pole. On this occasion he was away for four years, and he made some remarkable and difficult sledge journeys. In the spring of 1902 he set out over the Arctic Ocean, from the north coast of Grant Land, in another attempt to reach the pole. But at latitude 84° 17′ N. the route became impassable, and he had to turn back.

In the summer of 1905, however, he was back again amid the ice, and at the end of a year he came nearer to the pole than any other man had then attained. In all, Rear-Admiral Peary spent twelve years inside the Arctic Circle, and made eight voyages and six attempts to reach the pole. He always took the route through Smith's Sound, partly by reason of the fact that he found there a tribe of splendid Eskimos, who were the most northerly inhabitants of the earth. Much of his time was given to studying them, helping them, and making friends with them, for he foresaw from the first that they would be of the greatest use to him in his exploring work. The society that provided the funds for some explorer's expeditions began to despair of hearing that the American flag had been planted at the North Pole, but Peary was still undaunted. His courage and his perseverance increased under difficulties and disappointments until the man became practically a polar fanatic. Beneath all his fanaticism, however, there was a native shrewdness and an incomparable store of special knowledge of every detail of arctic exploration.

None of his achievements was a piece of wasted work. From each he learned something that helped him to his ultimate success. In 1908 a syndicate was formed in New York to subsidize him in his eighth voyage into the Arctic Ocean. By this time Peary had learned that the North Pole was, like Russia, mainly protected from attack by "General February". So his new expedition set out in large force early in the season, leaving its winter quarters in the middle of February. The party consisted of seven white men, seventeen Eskimos, with nineteen sledges and

one hundred and thirty-three dogs Having so large a staff, Peary was able to send a light advance party to prepare the trail, and then turn back successive divisions at different stages of the journey, leaving the final dash for the pole to be made by a small number of men, well equipped and comparatively fresh.

So excellently was the famous expedition planned and equipped that, far from suffering any ill effects from hard work and intense cold, the party increased in fitness and training as they advanced towards the pole. At a camp at 87° 47′ N., Captain Bartlett and the last supporting party returned, leaving Peary, a negro servant and three Eskimos to make the last dash. Peary took with him five sledges and forty of the best dogs. On April 1, 1909, he resumed his journey northward, hoping to reach the pole by five marches of twenty-five miles each.

At the end of the fifth day's march a sudden break in the clouds somewhere about noon enabled Peary to determine his position as 89° 57′. After resting for a few hours he set out with a light sledge, drawn by a double team of dogs, and, carrying only his instruments, went on for another ten miles Then, as the sky cleared, he took observations and found that he had gone beyond the pole.

He returned to camp, and struck eastward for eight miles, and there took more observations, and again found that he had reached and crossed the pole. Five miles from the strange, empty waste of ice that so many men had vainly given their lives to reach, Peary found a crack in the ice, and, boring a hole there, took a sounding of 9000 feet, and found no bottom.

ROBERT EDWIN PEARY, DISCOVERER OF THE NORTH POLE, WITH HIS DOGS

Having planted his flags on the hillock of ice representing the North Pole, Peary returned south by forced marches. The expedition reached Cape Columbia in such fine trim that the men crossed to Cape Hecla, and thence to the ship in two marches of forty-five miles each, a magnificent piece of work after the greatest and most difficult feat of exploration in history.

For more than a score of years the North Pole had been the object of Peary's every effort; he had spent nearly twelve years out of twenty-three, between his thirtieth and fifty-third birthdays, in the frozen wilderness

No man had ever worked so hard at the task, so none so thoroughly deserves the fame which Rear-Admiral Peary won. He received the thanks of Congress, was promoted rear-admiral, received gold medals from various geographical societies, and was made Grand Officer of the Legion of Honor of France. The claims of Dr. Frederick A. Cook of having reached the pole a year earlier were proved false.

MARCO POLO
The Greatest of all Land Explorers

IN 1260, eighteen years after the Mongols had established their rule from Poland to China, two Venetian noblemen set out from Constantinople on a trading venture in the Crimea The Crusaders still held the coast of Syria, and the Christians of Europe, having beaten back the Mongols, hoped to turn these terrible enemies against the Mohammedans. The two Venetian patricians were Maffeo and Nicolo Polo; they were brothers, and Nicolo had married and left his wife at Venice, where, unknown to him, she gave birth to a boy; Marco Polo.

In the Crimea the adventurous merchant-princes found a remarkable opening for commerce. The Mongols, rich with the spoils of half the world, eargerly welcomed them; and by following every opportunity the Polos traveled at last right across Asia, and arrived in China at the court of Kublai Khan. The Mongol emperor was delighted with the two Venetians, and much entertained with the tales they told him of European life and inventions. He came to the conclusion that the Christian religion would be an excellent instrument for civilizing his savage hordes, and he sent the Polos as his ambassadors to the Pope, asking for a hundred missionaries to convert his people.

The brothers arrived at Acre, in the Holy Land, in April, 1269, and there heard that the Pope was dead, and no successor yet appointed. Two years passed before the cardinals chose a new Pope. In the meantime the Venetian explorers returned to their native city, and Nicolo found that his wife was dead, leaving him a son, the famous Marco, then about fifteen years old.

In November, 1271, the two Polos set out from Acre, and Marco, thrilling with youthful zest for the great adventure, accompanied them. The travelers struck out for Bagdad, and, reaching the Persian Gulf, turned northward through Kerman, Khoristan and Balkh. Crossing the upper Oxus, they went over the Pamir highlands, and arrived at the awful desert of Taklamakan. Skirting it, they passed by Khotan,

MARCO POLO

and other towns now buried in the sands, and reached Lake Lop — never again to be seen by Europeans until the nineteenth century — and from there they traversed the great desert of Gobi, and, entering China, reached the court of the Kublai Khan in May, 1275.

The emperor took very kindly to Marco, now a young man of twenty-one. Up to this time Marco had owed everything to the courage and experience of his father and uncle. Theirs was entirely the credit for the two most remarkable feats of land exploration known to history, ranking in importance with that of Columbus, and, indeed, directly inspiring him, hundreds of years later, with the idea of his voyage.

At the court of Kublai Khan, Marco began to distinguish himself. He studied the languages and written characters of the diverse races governed by the Mongolian emperor; and partly out of personal liking for the young Venetian, and partly out of admiration for his talents, he appointed him a government officer.

This part of Marco Polo's story is confirmed by the Chinese annals of the Mongol dynasty. It is therein recorded that in 1277 Polo was made a second-class commissioner. In the course of his duties, Marco explored the Chinese provinces of Shansi, Shensi and Szechwan. Knowing that Kublai Khan delighted in tales of the strange manners and oddities of nations, Marco collected all the curious facts likely to interest the Mongol ruler. He did this especially in his travels through eastern Tibet and Yunnen, and on returning to court he rapidly rose in favor. For three years he governed Yangchau, and in his wandering roamed south to Cochin-China.

In the meantime, his father and uncle had been helping Kublai Khan in his wars, by constructing for him new and powerful engines of attack. Naturally, the three Venetians became very wealthy while enjoying the friendship of the mightiest ruler in the world. But, when they spoke of returning to Europe, the emperor refused to let them depart. They had become too valuable to him in many ways.

Happily, the fame of the Venetians had spread to Persia, where a great-nephew of Kublai Khan reigned, and he sent to China for a bride of his own tribe. His ambassadors asked that the Polos might also come to Persia, and Kublai Khan at last agreed to this, and gave the Venetians messages to the king of England and other European rulers. As there was war along the land route from China to Persia, the bridal party went by sea, leaving China in 1292. The expedition stayed at Sumatra and southern India, where Polo collected much information about these unknown parts of the world. It was two years and more before Persia was reached, and the Polos did not get back to Venice until 1295.

They came back dressed in Tartar costume, and they had half forgotten their mother tongue. Even their closest relatives refused to acknowledge that they were the Polos. But they gave a magnificent feast, dressed in the rich attire of their own nobility, and after dinner they brought out their rough Tartar dresses, and ripped them open, revealing the wealth of diamonds, rubies, emeralds and other precious stones they had won in their adventures. So their relatives no longer held back from them!

The Polos became famous, and the next year Marco was given the command of a galley in a sea-fight with the Genoese. The Venetians were completely defeated, and, with a multitude of his comrades, Marco was captured and imprisoned at Genoa. He spent his term of imprisonment in dictating in French the story of his travels in Asia to Rusticiano, a fellow-prisoner from Pisa, by whom it was entitled "The Book of Marco Polo". It was immediately translated into many languages, and for centuries comprised all the knowledge Europe possessed of the extreme East. Released from prison, Marco returned to Venice and married happily. He died in 1324.

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